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[54]		-	NG/EXPANDING IG CRYOGENIC TUBE SEALS
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[52]	U.S. Cl		
[58]	Field of S		277/26, 170, 207 A, 7236; 285/187, 328, 330, 332, 332.2, 341, 369, 904, 917
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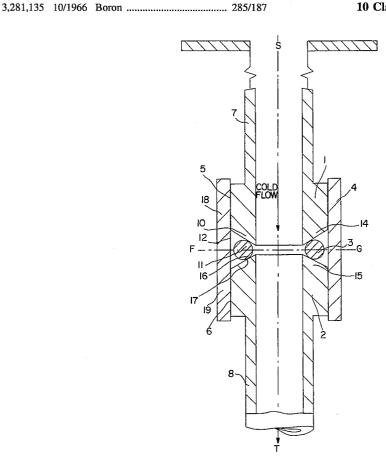
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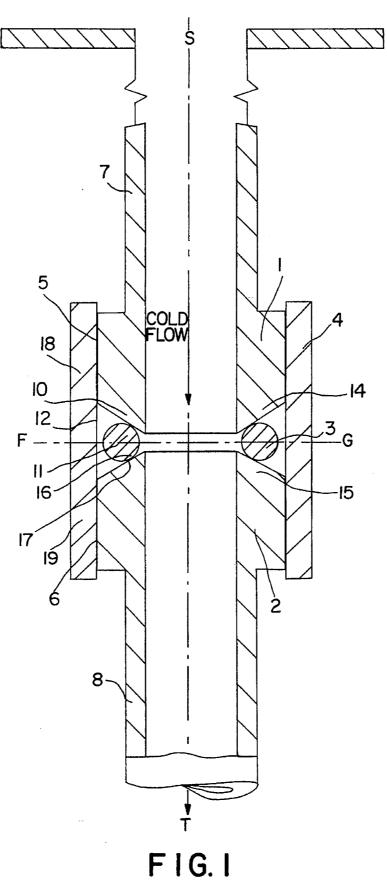
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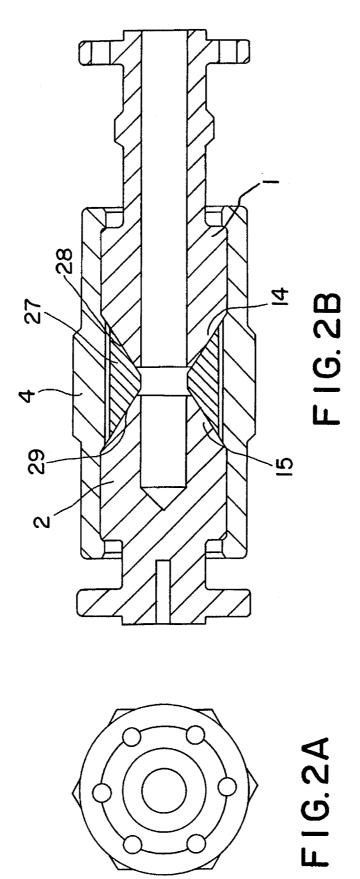
ABSTRACT [57]

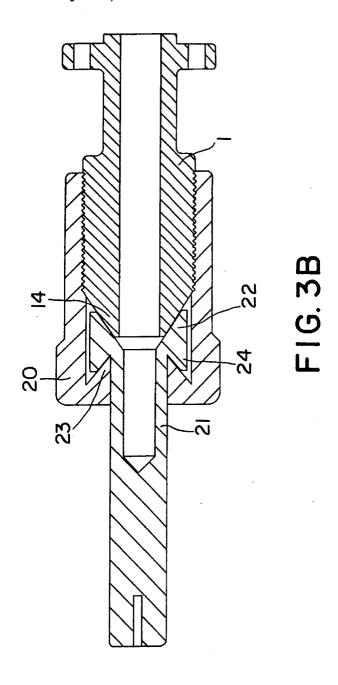
Contracting/expanding self-sealing cryogenic tube seals are disclosed which use the different properties of thermal contraction and expansion of selected dissimilar materials in accord with certain design criteria to yield self-tightening seals via sloped-surface sealing. The seals of the subject invention are reusable, simple to assemble, adaptable to a wide variety of cryogenic applications.

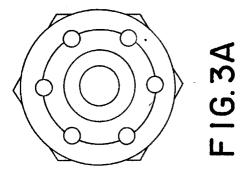
10 Claims, 12 Drawing Sheets

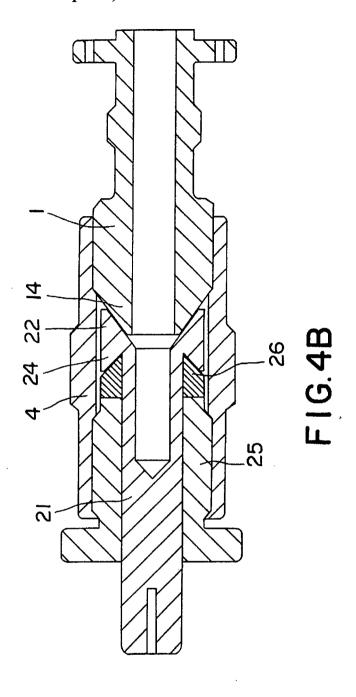


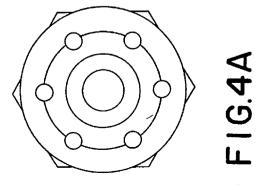


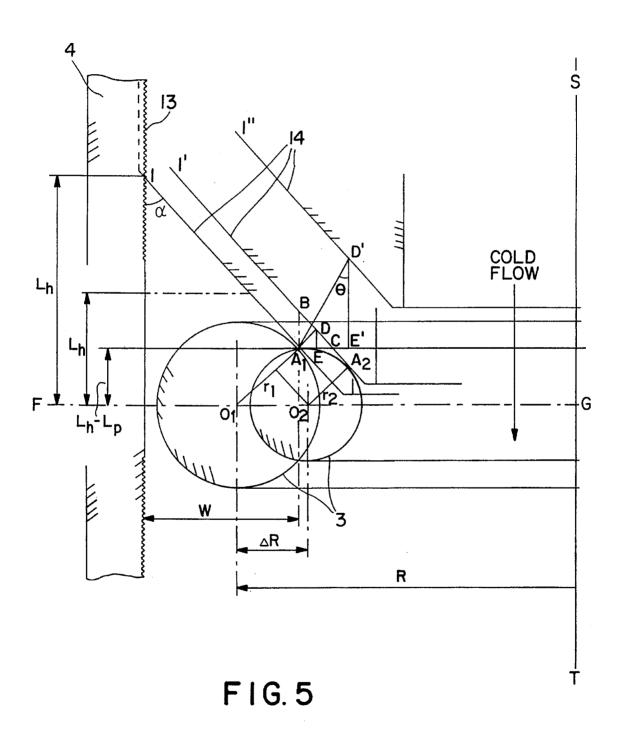


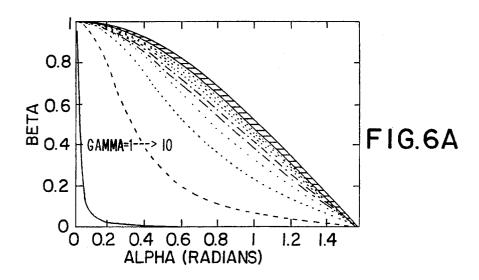


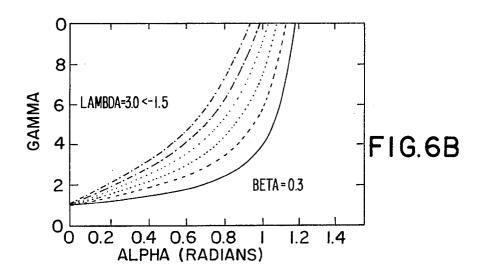


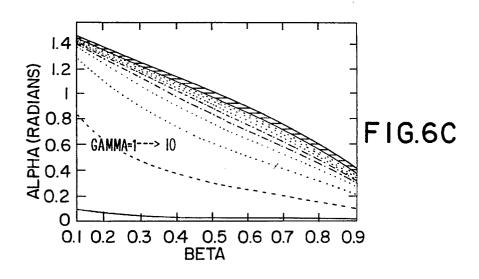


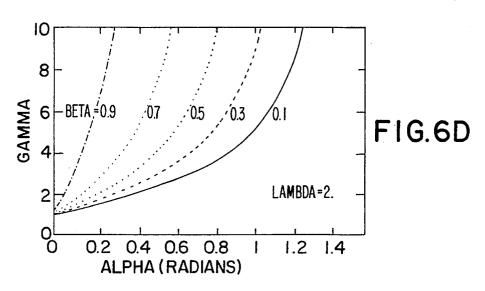




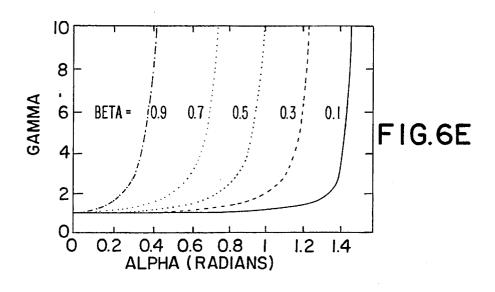


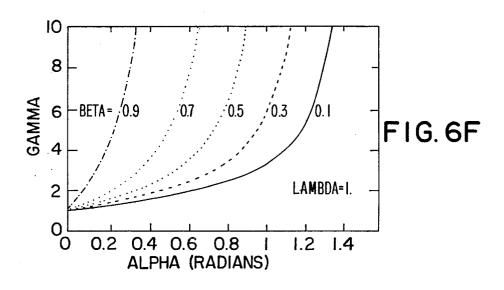


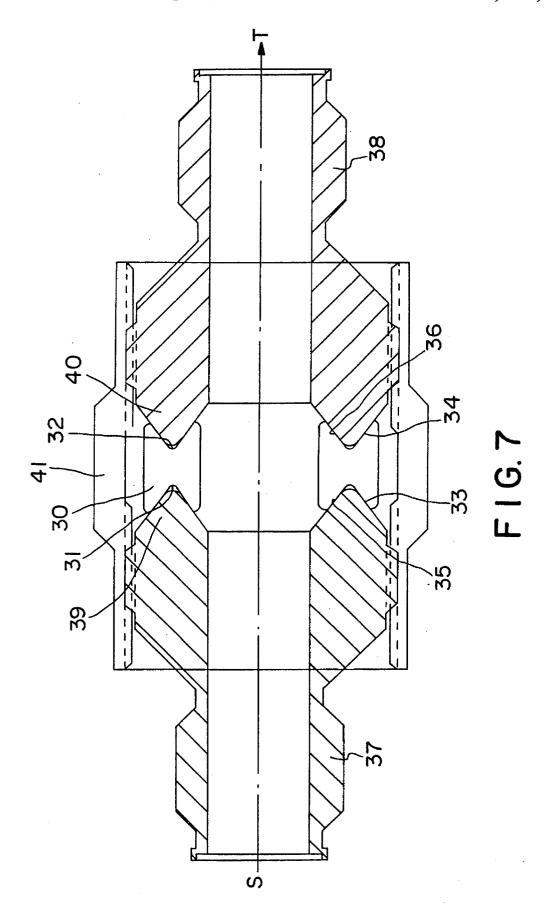


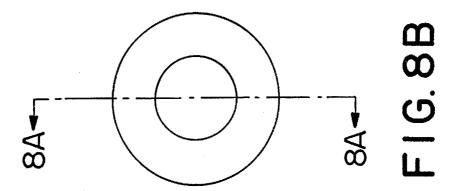


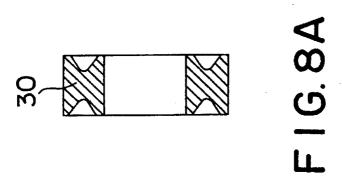
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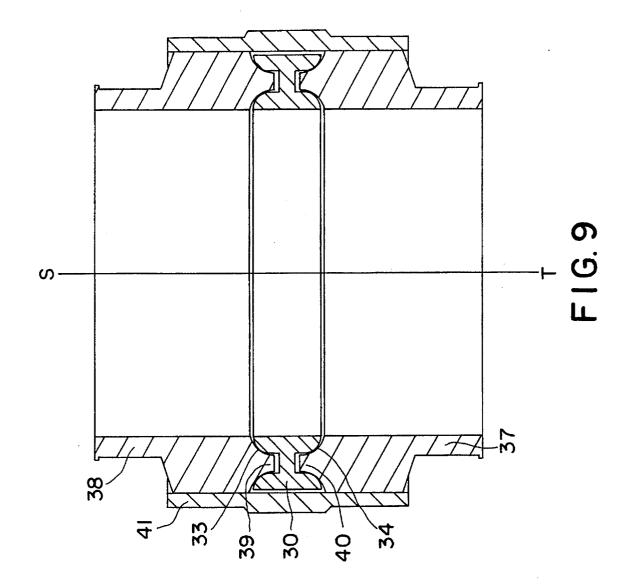












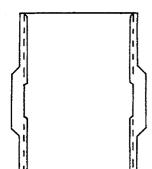
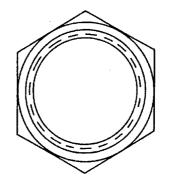
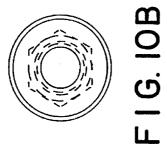


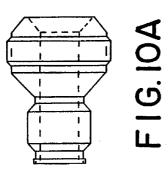
FIG.IIA

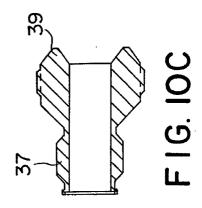


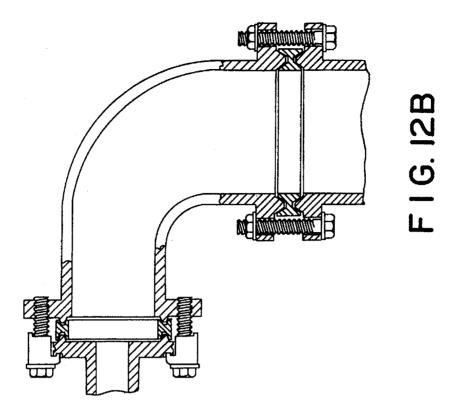
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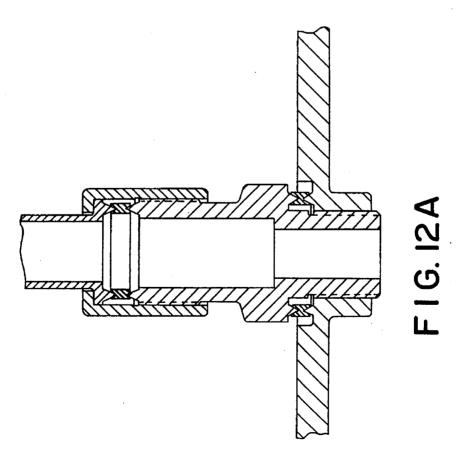


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CONTRACTING/EXPANDING SELF-SEALING CRYOGENIC TUBE SEALS

The subject invention was made with government support under a research project supported by NASA-Kennedy 5 Space Center and under Contract No. NAS10-11569 and Research Grant No. NAG10-0083. The government has certain rights in this invention.

This is a division of application Ser. No. 08/071,418, filed Jun. 1, 1993.

BACKGROUND OF THE INVENTION

The rigorous conditions of very low operating temperatures coupled with high pressure impose extreme difficulties for controlling cryogen leakage from in-line tube fittings. The KC126 fitting, which has been used by NASA in the fuel lines of the space shuttle, has been found to leak. We have shown that the KC126 fitting leaks at 205K, and at 77K has a leak mass flux of 1.28×10^{-3} kg/min. See also Moore, Z., 20 D. Capellin, A. Rodriguez, J. England (1988) "LH₂ TSM Leakage Problem," Interim Report: DM-MED-4, NASA, J. F. X. Space Center. Accordingly, there exists a need for an improved design of cryogenic seal for tube fittings such as those used in the space shuttle, and which is reusable and seals under extremes of low temperature and high pressure. Such a seal would have wide application in the cryogenic art.

The problem of sealing a joint between taro interconnecting pieces that are designed to operate at cryogenic tem- 30 peratures has been previously recognized. In pan, this problem was addressed in U.S. Pat. No. 3,630,533, issued Dec. 28, 1971 to Butler et al., entitled "Dynamic Seal for Cryogenic Fluids." An additional problem addressed by Butler et al. is the high temperature sealing problem, which influ- 35 enced Butler et al.'s design. Butler et al. used a circular sealing ring made from a fluorocarbon plastic material to seal two metal tubular couplings. The sealing ring is pressed onto a radially outward surface of one of the metal couplings. The sealing ring has a radially inward protruding 40 annular rib which elastically and inelastically deforms as the sealing ring is pressed into place. This arrangement effects a sealing engagement between the sealing ring and the metal coupling at temperatures reported to be within the range of 70° F. to -423° F. At normal temperatures, the inner surface 45 of the sealing ring is held in sealing engagement by the elastic preload induced by the initial interference press-fit and deformation of the protruding annular rib. In addition to the preload, a circumferential tension is generated in the sealing ring as the temperature decreases, because the seal- 50 ing ring's coefficient of thermal expansion and contraction is greater than the coefficient of thermal expansion and contraction of the metal couplings. Thus, because of the differences in the expansion coefficients of the sealing ring and the metal coupling that it is pressed onto, the sealing engagement between these members of two different materials becomes tighter as the temperature decreases. However, in Butler et al.'s design, each time two metal tubular couplings are sealed together, the complex plastic sealing ting must be inelastically deformed into a particular configuration. Since 60 the sealing ting is irreparably deformed by its installation, after separation of the two couplings for maintenance or other reasons, it is necessary to replace the sealing ting before the two couplings can be rejoined. Such a "use once and throw away" approach is wasteful, ultimately expensive, 65 and troublesome if a replacement ring is not readily available. A coupling between two members which can be joined

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and separated, without requiring a new sealing ring each time, is needed.

BRIEF SUMMARY OF THE INVENTION

The subject invention, contracting/expanding self-sealing cryogenic tube seals, are thermal-contraction controlledaction sealing and gripping devices which utilize the differences of the thermal contraction of selected dissimilar materials in a specially designed and composed structure to self-tighten the seal via sloped-surface sealing between coupled members as the temperature decreases from ambient temperature. "Sloped-surface sealing" means that the contact points creating the seal are not the result of contact of parallel surfaces. In one preferred embodiment, the cooling process causes the contraction of a sealing spacer, further gripping the member ends, and causes the contraction of a housing nut, further forcing the coupling member ends together, thereby taking advantage of sloped-surface sealing in a novel way and preventing leakage of the flowing cryogen.

The contracting/expanding serf-sealing cryogenic tube seals are leak-free from room temperature to cryogenic temperatures as low as that of liquid helium and, unlike anything known in the an, provide easily remountable tube connections for high pressure and low temperature applications.

The contracting/expanding self-sealing cryogenic tube seal is a general purpose cryogenic tube seal. It provides reliable leak-free connections for the low/high pressure and low temperature working conditions in cryogenic applications. It can be easily applied to various cryogenic fittings and valves. Some basic advantages of contracting serf-sealing cryogenic fittings are summarized as follows:

- 1. Applicable to any low temperatures and temperature cycling.
- 2. Works on most common magnetic/non-magnetic tube materials.
 - 3. Seals on machined surfaces.
 - 4. Does not reduce the flow area.
 - 5. Works on vacuum as well as low or high pressures.
 - 6. Simple in structure for production and handling.
 - 7. Easy to use, similar to the standard SAE fittings.
 - 8. Easy to assemble and disassemble.
- 9. Ability to reuse without special maintenance or replacement.
 - 10. Not sensitive to the applied coupling torques.
 - 11. Not sensitive to the moment from other components.
 - 12. Not corrosive for common cryogen.
 - 13. Applicable to most cryogenic tube connections.

Design criteria for contracting/expanding self-sealing cryogenic (CESSC) tube seals are taught which must be applied in accord with the subject invention, and which depend on the properties of selected materials as well as the configuration of the seal. These criteria, illustrated by the following examples, enable the construction by means well known in the art of a tremendous number of varying embodiments, all of which are based on the novel sloped-sealing concepts taught herein, as will be readily apparent to the skilled artisan.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 depicts a longitudinal section through a preferred embodiment of a contracting self-sealing cryogenic tube seal

- FIG. 2 depicts a longitudinal section through a variation of the embodiment depicted in FIG. 1, wherein the O-ring spacer has been replaced with a modified spacer.
- FIG. 3 depicts a longitudinal section through an alternative embodiment of a contracting self-sealing cryogenic tube 10 seal having only three components.
- FIG. 4 depicts a longitudinal section through an alternative embodiment of the contracting self-sealing cryogenic tube seal.
- FIG. 5 depicts the geometric analysis of cryogenic shrinkage of the components of the contracting self-sealing cryogenic tube seal.
- FIG. 6 is a graphic representation of the design criteria for the contracting self-sealing cryogenic tube seal.
- FIG. 7 depicts a longitudinal section through a preferred embodiment of a contracting/expanding self-sealing cryogenic tube seal.
- FIG. 8 is a schematic drawing of an H-shaped spacer of a preferred embodiment of the contracting/expanding self- 25 sealing cryogenic tube seal.
- FIG. 9 depicts an H-shaped spacer of the contracting/ expanding self-sealing cryogenic tube seal wherein the sloped surface sealing is accomplished via contact of curved surfaces.
- FIG. 10 is a schematic drawing of a preferred embodiment of a coupling member of the contracting/expanding self sealing cryogenic tube seal.
- FIG. 11 is a schematic drawing of a preferred embodiment of the housing nut of the contracting/expanding self sealing cryogenic tube seal.
- FIG. 12 depicts various embodiments of the contracting/ expanding self sealing cryogenic tube seal in potential operational configurations.

DETAILED DISCLOSURE OF THE INVENTION

Following are examples which illustrate procedures, including the best mode, for practicing the invention. These examples should not be construed as limiting.

Example 1-A Preferred Embodiment

In a preferred embodiment, as depicted in FIG. 1, the contracting self-sealing cryogenic tube seal consists of four basic components: metal coupling members 1 and 2, each having a male an-flare tube end 14 and 15, respectively, an O-ring spacer 3, and a housing nut 4. Housing nut 4 comprises internal threads 13 for threaded engagement with external threads 5 and 6 on coupling members 1 and 2, respectively. The O-ring spacer 3 rests between two male an-flare coupling members 1 and 2.

Various pans of contracting serf-sealing cryogenic tube 60 seals are made of dissimilar solid bar metals, thereby taking advantage of their different coefficients of thermal contraction. The materials for O-ring spacer 3 and housing nut 4 have higher values of the coefficient of thermal contraction than does the material used for coupling members 1 and 2. 65 In the preferred embodiment, the components are axisymmetric (symmetric about an axis).

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Assembly of the contracting self-sealing cryogenic tube seal depicted in FIG. 1 is a simple matter of engaging housing nut 4 with coupling member 1 until the an-flare tube end 14 of coupling member 1 is positioned approximately in the middle of housing nut 4, proximal to the lateral plane represented by segment FG. O-ring spacer 3 is then inserted into homing nut 4 until it contacts an-flare tube end 14 of coupling member 1. Coupling member 2 is then engaged into housing nut 4 until an-flare tube end 15 is secured against O-ring spacer 3. The sloped surface of the an-flare tube ends allows for contraction of the spacer while ensuring that a tight seal is maintained.

In operation, cryogenic fluid begins to flow through the contracting self-sealing cryogenic tube fitting along longitudinal axis ST as depicted in FIG. 1. For ease of discussion, movement toward position S will be referred to as "upward" and movement toward position T will be referred to as "downward;" movement toward axis ST will be referred to as "inward" and movement away from axis ST will be referred to as "outward." As the cryogenic fluid flows, the temperature of all pans of the contracting self-sealing crvogenic tube seal begins to decrease. Accordingly, the various pans of the tube seal shrink in size. Contact portion 10 at tube end 14 tends to shrink upward and inward. Contact portion 11 at O-ring spacer 3 tends to shrink downward and inward. That portion 18 of housing nut 4, which is depicted above lateral plane FG, tends to shrink downward and inward, while housing nut portion 19, below plane FG, tends to shrink upward and inward. Because O-ring spacer 3 and housing nut 4 are made of materials having a larger coefficient of thermal contraction than are coupling members 1 and 2 (and thus tube ends 14 and 15), the inward shrinkage of O-ring spacer 3 tends to cause it to press even more tightly against tube ends 14 and 15. Similarly, shrinkage of housing nut 4 tends to force tube ends 14 and 15 toward each other, as well as providing a tighter engagement of threaded portions 13, 5, and 6. Thus, the effects of thermal contraction will always maintain a leak-free seal in the contracting self-sealing cryogenic seal.

Example 2—Some Alternative Embodiments

FIGS. 2, 3, and 4 depict exemplary alternative embodiments of the subject invention. To ensure proper sealing, contact surfaces of the components are axisymmetric. FIG. 2 depicts an embodiment similar to that depicted in FIG. 1 except that O-ring spacer 3 has been replaced with a flared spacer 27 having opposed female-flared contact surfaces 28 and 29, each having a complementary shape to tube ends 14 and 15, respectively, such that a tight seal is maintained therebetween in accord with the design criteria described hereinafter.

FIG. 3 depicts coupling member 1 with male an-flare tube end 14, coupling member 21 with female flare tube end 22, and housing nut 20, having a large bore at one end with internal threaded means for receiving and engaging coupling member 1 and a smaller (step down) bore at the other end, which is just large enough to surround coupling member 21, but not large enough to allow female flare tube end 22 to pass through. The internal surface of the step-down end of housing nut 20 defines a circumferential flange 23, radially sloping downward and outward. Housing nut 20 engages coupling member 1, and as housing nut 20 is tightened about coupling member 1, flange 23 engages a circumferential lip 24 on coupling member 21, lip 24 having a complementary slope to that of flange 23 such that contact is maintained between lip 24 and flange 23, and pulls coupling member 21

such that the female flare tube end 22 of coupling member 21 is thereby brought into contact with male an-flare tube end 14 of coupling member 1, similar to the method by which a garden house is brought into contact with a spigot. Secured contact between tube end 14 and tube end 22 is 5 thereby maintained in accord with the disclosed design criteria. To maintain the sloped-surface seal of this embodiment leak-free at cryogenic temperatures, coupling member 21 and housing nut 20 are made of materials having a larger coefficient of thermal expansion than the material of coupling member 1, all in accord with the design criteria. For example, coupling member 21 and housing nut 20 may be made of copper, if coupling member 1 is stainless steel.

The embodiment depicted in FIG. 4 combines features of the embodiments depicted in FIGS. 1 and 3. Housing nut 4 is engaged with coupling member 1 until the an-flare tube end 14 of coupling member 1 is positioned approximately in the middle of housing nut 4. Housing nut 4 then engages collar 25, which has external threaded means for being engaged and secured by the internal threaded means of housing nut 4, and which also has a wedge end 26 which engages lip 24 on coupling member 21 and forces female flare tube end 22 into secured contact with male an-flare tube end 14. Thus, it can be seen that the collar and wedge component of this embodiment can be used with housing nut 25 4 to effectively replace the flange 23 and small bore end of housing nut 20 of the embodiment depicted in FIG. 3. To maintain the sloped-surface seal of this embodiment leakfree at cryogenic temperatures, collar 25 (having wedge end **26**), as well as coupling member 1, are made of materials having a smaller coefficient of thermal expression than the material of housing nut 4 and coupling member 21 (having lip 24).

Example 3—Design. Criteria of Contracting/Expanding Self-Sealing Cryogenic Seals

According to the theory of Gas Dynamics and the linear 40 analysis of thermal contraction, some criteria for the design of contracting/expanding self-sealing cryogenic seals are given below:

(1) Design criteria for two components—tube and spacer:

$$\alpha < \cos^{-1}\left\{ \left[\gamma_o + \left(\frac{\gamma_o - 1}{2\beta} \right)^2 \right]^{\frac{1}{2}} - \frac{\gamma_o - 1}{2\beta} \right\}$$

$$\beta < \frac{\gamma_o - 1}{\frac{\gamma_o}{\cos(\alpha)} - \cos(\alpha)}, \gamma_o > \frac{1 - \beta\cos(\alpha)}{1 - \frac{\beta}{\cos(\alpha)}}$$

(2) Design criteria for three components—housing nut, tube-end, and spacer:

$$\gamma_o(T) > \frac{C_1(T)}{C_2}$$

where

$$C_1(T) = \sin \left[\alpha + \tan^{-1} \left(\frac{1 - \beta \cos \alpha}{\frac{\lambda}{\tan \alpha} (1 - \gamma_h(T)) - \gamma_h(T)\beta \sin \alpha} \right) \right].$$

$$\left[(1 - \beta \cos \alpha)^2 + \left(\frac{\lambda}{\tan \alpha} (1 - \gamma_h(T)) - \gamma_h(T)\beta \sin \alpha \right)^2 \right]^{1/2}$$

$$C_2 = (\cos \alpha - \beta)$$
65

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Referring to FIG. 5, a is the an-flared angle of the tube ends. fi is the radius ratio of O-ring spacer r_1/R . λ is the ratio of the thickness of tube-end to the radius of the spacer, $\gamma_0(\gamma_o=\epsilon_o/\epsilon_p)$ is the ratio of thermal contraction of the material used for the spacer to that of the tube ends $\gamma_5(\gamma_h=\epsilon_h/\epsilon_p)$ is the ratio of thermal contraction of the material used for the housing-nut to that of the tube ends. The parameters, α , β , and λ , are the parameters of the seal geometry. γ_o and γ_h are the functions of temperature, which can be found from the tables of material properties and are well known in the art.

These criteria have been illustrated in the graphs of FIG. 6. The physics of the thermal contracting process or the thermal and geometric effects of the contracting/expanding self-sealing cryogenic seal is revealed by these criteria. The contracting/expanding self-sealing cryogenic seal is predictable in its response to temperature fluctuations-it consistently fulfills the promise of self-sealing for cryogenic applications.

A linear approximation of the sealing process in a thermal-contraction controlled-action seal by a simple geometric analysis was used to calculate design parameters of the contracting/expanding self-sealing cryogenic seal. The contracting serf-sealing cryogenic tube seals exemplified herein were designed in accord with this analysis and have successfully passed a series of tests in the cryogenic leak test system with a temperature drop from room temperature down to the liquid helium temperature in the Cryogenic Laboratory of Florida Atlantic University.

Shown in FIG. 5 is the cross-section of an O-ring spacer seated between an-flared tube ends with axial angle, α , before and after cooling period. Both O-ring spacer and tube end, which have different coefficients of thermal expansion, shrink axisymmetrically in the cooling process. A_1 and A_2 are two contact points of the mating pans before and after cooling. Because of the thermal contraction, the original contact point, A_1 , in the tube end moves to D, with a radial shrinkage, $\Delta t=A_1E$, and an axial shrinkage, $\Delta L=ED$.

A maximum value of the shrinkage of the tube end in axial direction, ΔL , can be obtained if presuming a zero-thermal-stress condition, which means free contracting of both O-ring spacer and tube end without losing contact with each other. It is apparent that if the actual axial shrinkage of the tube end is larger than the zero-thermal-stress shrinkage, ΔL , the contracting self-sealing cryogenic seal will never achieve a leak-free scal.

From the geometry in FIG. 5, if we let $\Delta L = A_1 B$ and $\Delta t = A_1 C$, then

$$\frac{\Delta L}{\Delta L'} = \frac{\Delta t' - \Delta t}{\Delta t'}$$

and $\Delta t' = \Delta L' \tan \alpha$, we have

$$\Delta L = \Delta L' - \frac{\Delta t}{\tan \alpha} \tag{1}$$

and also

 $\Delta L \sin \alpha + r_1 = \Delta R \cos \alpha + r_2$

we have.

$$\Delta L' = \frac{\Delta R}{\tan \alpha} - \frac{\Delta r}{\sin \alpha} \tag{2}$$

where $\Delta r = r_1 - r_2$. Combining Eq. (1) and (2),

$$\Delta L = \frac{1}{\tan \alpha} \left(\Delta R - \Delta t - \frac{\Delta r}{\cos \alpha} \right)$$
 (3)

Assuming a linear contraction as a first approximation, 5 i.e., $\Delta R = \epsilon_a R$, since r is much smaller than R, and $\Delta r = \epsilon_a r_1$ and $\Delta t = \epsilon_p (R - r_1 \cos \alpha)$ for the same approximation, where e_o and e_p are the coefficients of thermal expansion of O-ring spacer and tube end, respectively. Substituting ΔR , Δt , and Δr into Eq. (3), we have,

$$\Delta L = \frac{1}{\tan \alpha} \left[R(\epsilon_o - \epsilon_p) - r_1 \left(\frac{\epsilon_o}{-\cos \alpha} - \epsilon_p \cos \alpha \right) \right]$$
 (4)

Let $\gamma = \epsilon_o / \epsilon_p$, and $\beta = r_1 / R$, we can rewrite Eq. (4) as

$$\Delta L = \frac{R\epsilon_p}{\tan \alpha} \left[\gamma \left(1 - \frac{\beta}{\cos \alpha} \right) + \beta \cos \alpha - 1 \right]$$
 (5)

The maximum axial shrinkage of tube end, ΔL , from the above equation, is a function of three parameters, α , β , and γ , where α is the an-flared angle of the tube end, β is the 20 radius ratio of the O-ring spacer, and γ is the ratio of thermal properties of material used for two mating parts.

In order to have a positive value of ΔL , the term in brackets must be positive, which leads to three design criteria for three parameters, each one depending on the 25 other two, which are given as follows:

$$\gamma > \frac{1 - \beta \cos\alpha}{1 - \frac{\beta}{\cos\alpha}} \tag{A}$$

$$\beta < \frac{\gamma - 1}{\frac{\gamma}{\cos \alpha} - \cos \alpha}$$
 (B)

$$\alpha < \cos^{-1} \left\{ \left[\gamma + \left(\frac{\gamma - 1}{2\beta} \right)^2 \right]^{\frac{1}{2}} - \frac{\gamma - 1}{2\beta} \right\}$$
 (C)

According to the above criteria, α and β do not have lower limitations except for the negative values, which are meaningless for an O-ring seal. The lower limitations actually depend on the strength of the materials. The minimum value 40 of a depends on the requirement for the wall thickness of the tube end. The minimum value of fi depends on the requirement for the radius of the cross section of the O-ring spacer. The graphs of FIG. 6 represent possible values for α , β , and γ that can be used for the design of contracting self-sealing cryogenic seal. In Table 1 a dimensionless parameter of $\Delta L/R\epsilon_p$ is given which is computed from Eq. (5) for the convenience of applications. For example, if we choose $\alpha=35^{\circ}$, and $\beta=0.3$, then γ must be larger than 1.2. If we chose γ =6 (for copper O-ring and invar tube end), we have ⁵⁰ $\Delta L/R\epsilon_p$ =4.5. If R=8 mm, and ϵ_{op} =0.06% (invar at 6K), the maximum promising axial shrinkage, ΔL=0.022 mm. This is an approximate value for the tested contracting self-sealing cryogenic seal at liquid helium temperature.

Example 4—Selection of Materials for Contracting/Expanding Self-Sealing Cryogenic Seals

The function of a contracting/expanding self-sealing 60 cryogenic seal relies upon the differences of the thermal contractions of dissimilar materials in a specially composed structure which, in a novel, advantageous manner uses the Concept of sloped-surface sealing. The selection of materials is basically determined by the nature of thermal contraction of the materials used for each of the components. The contracting/expanding self-sealing cryogenic seal works

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only if it is designed to meet the criteria which are dependent upon not only the thermal properties of materials, but also the geometric parameters. The selection of the materials, therefore, is not an independent factor in order to achieve a self-sealing purpose. It must be considered together with the geometric parameters of the components of the seal. In this regard, the contracting self-sealing cryogenic seal is an integrated unit.

One of the possible combinations is given as follows: The material for tube ends is commonly the same as that for the tubing bodies. For cryogenic situations, stainless steel is a commonly-used material for tubing bodies. Therefore, among other common engineering materials, in the embodiment depicted in FIG. 1, copper is one of the possible choices for the housing nut and the O-ring spacer, used with the stainless steel tube ends. However, the geometric configuration must meet the contracting serf-sealing cryogenic criteria disclosed above with the given parameter of thermal contraction ratio calculated for copper to stainless steel.

Example 5—Test Results of Various Embodiments of Contracting Self-Sealing Cryogenic Seal

The contracting self-sealing cryogenic seals have passed a series of tests in the cryogenic leak test system at Florida Atlantic University. The detailed information of the cryogenic leak test system is given in Jia, L. X., D. Moslemian, W. L. Chow (1992) "Cryogenic leak testing of tube fittings/ valves," Cryogenics 32(9):833-839, which is incorporated 30 herein by reference thereto. The tests were conducted under two different temperature levels, LN₂ temperature (≈77K), and LHe temperature (\approx 4K).

For the leak test under LN₂ temperature, the highest internal pressure against the external vacuum applied to this seal has been 31×10^5 Pa, nearly two times the working pressure in the space shuttle. The test lasted about ten hours without showing any signs of leak from vacuum gauges at pressure of 5×10^{-4} Bar within the sample chamber. In another test, initial pressurization was to 27.1×10^5 Pa. As the temperature dropped to 140K, additional gaseous helium was supplied to increase the internal pressure from 12×10⁵ Pa to 26.2×10⁵ Pa. When the equilibrium temperature of 77K was reached, internal pressure was reduced down to 17.2×10⁵ Pa and kept under this condition for another 10 hours. Throughout the testing period, no pressure increase was detected in the evacuated sample chamber used to house the seal.

For the leak test under LHe temperature, a constant internal pressure of 27.1×10⁵ Pa against the external vacuum was applied to the contracting self-sealing cryogenic tube seal. The test lasted 5 hours at the temperature of 4.5K~6.9K without showing any signs of leak from vacuum gauges at pressure of 1×10^{-6} Bar within the sample chamber. The tests on the contracting self-sealing cryogenic tube seals at LHe temperature indicated that it is feasible to develop a new series of cryogenic tube seals for the LH2 transfer lines of the space shuttle, as well as for other cryogenic applications, based on the novel sloped-sealing technology taught herein.

Example 6—Contracting/Expanding Self-Sealing Cryogenic Seal

The concept for a contracting self-sealing cryogenic tube seal can be extended for a special application where a wide range and high rate of temperature cycling is a significant feature of the working condition. A contracting/expanding self-sealing cryogenic tube fitting is schematically shown in FIG. 7. With larger thermal contraction and thermal expansion coefficients, the shrinking or expanding displacement of the spacer caused by temperature cycling always tends to prevent the appearance of any possible leak gap between the tube ends and the spacer, no matter whether the working temperature is decreasing or increasing. A similar analysis for a contracting/expanding self-sealing cryogenic seal can be easily obtained as described above by considering an additional reverse thermal process of temperature increase.

In a contracting/expanding self-sealing cryogenic seal as 10 depicted in FIG. 7, the spacer 30 has an H-shaped crosssection, having opposed V-shaped female sloped-sealing surfaces 31 and 32 at each end which contact the complementary sloped male an-flare tube ends 39 and 40, respectively, of the coupling members 37 and 38. The male angle $_{15}$ of the tube end is made slightly larger than the female angle of the corresponding surface of the spacer 30. A similar H-shaped spacer/seal is depicted in FIG. 9, wherein the sloped surface sealing is accomplished by contact of curved surfaces. When temperature is decreased, the outwardmost 20 contact surfaces 33 and 34 of the spacer 30 will tightly grip the tube ends 39 and 40. When temperature is increased, the inside contact surfaces 35 and 36 of the spacer 30 will tightly press against the tube ends 39 and 40. Therefore, a fight seal is achieved under the temperature cycling condition. Since 25 the temperature changes in two opposite directions, the thermal behavior of the housing nut 41 no longer contributes consistently for tube sealing during the temperature cycling. Therefore, in a preferred embodiment, the material for the housing nut 41 has a smaller coefficient of thermal contrac- 30 tion (or expansion) than does the spacer 30. The material for coupling members 37 and 38 also has a smaller coefficient of thermal expansion than does that of spacer 30. The selection of materials for the spacer 30 and tube ends 39 and 40 of contracting/expanding self-sealing cryogenic seals 35 follows the same design criteria given above. In a preferred embodiment, the subject seal, seemingly sophisticated, surprisingly simply solves sometimes severe system seepage substantially superior to standard space shuttle seals by specially-selected, securely sandwiched, sloped-surface 40 spacers snugly surrounding stainless steel surfaces shown self-sealing by sequential shrinking and swelling.

One preferred embodiment of the contracting/expanding self-sealing cryogenic seal was fabricated for use in the LH₂ lines of the space shuttle at the JFK Space Center. The 45 H-shaped spacer 30 (see FIGS. 7 and 8) has a larger thermal expansion coefficient than that of the tube ends 39 and 40 between which it is sandwiched. Shrinkage or expansion of this spacer always tends to prevent the formation of any possible leaking gap between the tube ends and the spacer, 50 regardless of whether the working temperature is decreasing or increasing. The contracting/expanding serf-sealing cryogenic tube seal provides leak-free and easily remountable tube connections from temperatures as high as the component materials can withstand to cryogenic temperatures as 55 low as that of liquid helium, and under pressures varying from vacuum to several hundred psi or more. The seal is especially effective in applications where a wide range and high rate temperature cycling are significant features of the working conditions. The seal can be easily integrated into all 60 kinds of cryogenic tubing components, such as fittings and valves. Several possible configurations which employ the contracting/expanding self-sealing cryogenic tube seal are shown in FIG. 12. The contracting/expanding serf-sealing cryogenic seal has passed the temperature cycling test: first 65 cooled down from 296K to 12K, then heated up to 300K within 20 minutes, and then cooled down again to 77K,

while the pressure maintained 400 psig, without showing any sign of leak.

It should be understood that the examples and embodiments described herein are for illustrative purposes only and that various modifications or changes in light thereof will be suggested to persons skilled in the art and are to be included within the spirit and purview of this application and the scope of the appended claims.

TABLE 1

	Design Para	meters for CSSO	C Tube Fitting	g, (d1= $\Delta L/R\epsilon_p$).
gama(00000 alfa=	5) >	1.000848
11/	gama	beta	alfa	0.00000000
11(1.000848	0.1000000 0.1000000	5)=	0.0000000E+00
11(1.500848		5)=	5.141342
11(2.000848	0.1000000	5)=	10.28268
11(2.500848	0.1000000	5)=	15.42402
11(3.000848	0.1000000	5)=	20.56536
11(3.500848	0.1000000	5)=	25.70670
11(4.000848	0.1000000	5)=	30.84805
11(4.500848	0.1000000	5)=	35.98938
11(5.000848	0.1000000	5)=	41.13073
11(5.500848	0.1000000	5)=	46.27207
11(6.000848	0.1000000	5)=	51.41341
ama(l		00000 alfa=	10) >	1.003408
117	gama	beta	alfa	0.00000000
11(1.003408	0.1000000	10)=	0.0000000E+00
11(1.503408	0.1000000	10)=	2.547703
11(2.003408	0.1000000	10)=	5.095405
11(2.503408	0.1000000	10)=	7.643107
11(3.003408	0.1000000	10)=	10.19081
11(3.503408	0.1000000	10)=	12.73851
11(4.003408	0.1000000	10)=	15.28621
1(4.503408	0.1000000	10)=	17.83392
1(5.003408	0.1000000	10)=	20.38162
11(5.503408	0.1000000	10)=	22.92932
11(6.003408	0.1000000	10)=	25.47702
ama(l	neta= 0.100	00000 alfa=	15) >	1.007736
	gama 0.100	beta	alfa	1.007750
17		0.1000000		0.0000000000000000000000000000000000000
1(1.007736		15)=	0.0000000E+00
1(1.507736	0.1000000	15)=	1.672840
1(2.007736	0.1000000	15)=	3.345681
1(2.507736	0.1000000	15)=	5.018521
1(3.007736	0.1000000	15)=	6.691361
1(3.507736	0.1000000	15)=	8.364202
1(4.007736	0.1000000	15)=	10.03704
1(4.507736	0.1000000	15)=	11.70988
1(5.007736	0.1000000	15)=	13.38272
1(5.507736	0.1000000	15)=	15.05556
1(6.007736	0.1000000	15)=	16.72840
ama(ł	oeta= 0.100	00000 alfa=	20) >	1.013931
	gama	beta	alfa	
.1(1.013931	0.1000000	20)=	0.0000000E+00
1(1.513931	0.1000000	20)=	1.227548
1(2.013931	0.1000000	20)=	2.455097
1(2.513931	0.1000000	20)=	3.682646
1(3.013931	0.1000000	20)=	4.910194
.1(3.513931	0.1000000	20)=	6.137743
1(4.013931	0.1000000	20)=	7.365292
.1(4.513931	0.1000000	20)=	8.592841
	5.013931	0.1000000		9.820390
.1(20)=	
.1(5.513931	0.1000000	20)=	11.04794
.1(6.013931	0.1000000	20)=	12.27549
ama(l		00000 alfa=	25) >	1.022151
	gama	beta	alfa	
1(1.022151	0.1000000	25)=	0.0000000E+00
1(1.522151	0.1000000	25)=	0.9539434
1(2.022151	0.1000000	25)=	1.907887
1(2.522151	0.1000000	25)=	2.861830
1(3.022151	0.1000000	25)=	3.815774
.1(3.522151	0.1000000		
•				4.769717
.1(4.022151	0.1000000	25)=	5.723660
1(4.522151	0.1000000	25)=	6.677603
1(5.022151	0.1000000	25)=	7.631547

TARI	F '	1-continued
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TABLE 1-continued

	Design Para	meters for CSS	C Tube Fittin	g, (d1=ΔL/Rε _p).			Design Para	meters for CSS	C Tube Fittin	g, (d1= Δ L/R ϵ_p).	
dl(5.522151	0.1000000	25)=		5	d1(2.141690	0.1000000	55)=	0.5781302	-
dl(6.022151	0.1000000	25)=	9.539434		d1(2.641690	0.1000000	55)=	0.8671951	
						d1(3.141690	0.1000000	55)=	1.156260	
gama(00000 alfa=	30) >	1.032636		d1(3.641690	0.1000000	55)=	1.445325	
	gama	beta	alfa			d1(4.141690	0.1000000	55)=	1.734390	
d1(1.032636	0.1000000	30)=	0.0000000E+00		d1(4.641690	0.1000000	55)=	2.023455	
d1(1.532636	0.1000000	30)=	0.7660255	10	d1(5.141690	0.1000000	55) =	2.312521	
d1(2.032636	0.1000000	30)=	1.532051		dl(5.641690	0.1000000	55)=	2.601585	
dl(2.532636	0.1000000	30)≔	2.298077		d1(6.141690	0.1000000	55)=	2.890651	
dl(3.032636	0.1000000	30)=	3.064102					······································		_
d1(3.532636	0.1000000	30)=	3.830127		gama	(beta= 0.10	00000 alfa=	60) >	1.187500	
dl(4.032636	0.1000000	30)=	4.596153			gama	beta	alfa		
dl(4.532636	0.1000000	30)=	5.362179	15	d1(1.187500	0.1000000	60)=	0.0000000E+00	
d1(5.032636	0.1000000	30)=	6.128204	13	d1(1.687500	0.1000000	60)=	0.2309401	
d1(5.532636	0.1000000	30)=	6.894230		d1(2.187500	0.1000000	60)=	0.4618802	
d1(6.032636	0.1000000	30)=	7.660254		d1(2.687500	0.1000000	60)=	0.6928203	
						d1(3.187500	0.1000000	60)=	0.9237604	
gama(beta= 0.10	00000 alfa=	35) >	1.045747		d1(3.687500	0.1000000	60)=	1.154701	
	gama	beta	alfa			dl(4.187500	0.1000000	60)=	1.385641	
d1(1.045747	0.1000000	35)=	0.0000000E+00	20	d1(4.687500	0.1000000	60)=	1.616581	
d1(1.545747	0.1000000	35)=	0.6269017		d1(5.187500	0.1000000	60)=	1.847521	
d1(2.045747	0.1000000	35)=	1.253803		d1(5.687500	0.1000000	60)=	2.078461	
d1(2.545747	0.1000000	35)=	1.880705		d1(6.187500	0.1000000	60)=	2.309401	
d1(3.045747	0.1000000	35)=	2.507607					· · · · · · · · · · · · · · · · · · ·		
d1(3.545747	0.1000000	35)≕	3.134508		gama((beta= 0.10	00000 alfa=	65) >	1.254602	
d1(4.045747	0.1000000	35)=	3.761410	25		gama	beta	alfa		
d1(4.545747	0.1000000	35)=	4.388311		d1(1.254602	0.1000000	65)==	0.0000000E+00	
d1(5.045747	0.1000000	35)=	5.015213		d1(1.754602	0.1000000	65)=	0.1779849	
dl(5.545747	0.1000000	35)=	5.642115		d1(2.254602	0.1000000	65)=	0.3559698	
dl(6.045747	0.1000000	35)=	6.269017		d1(2.754602	0.1000000	65)=	0.5339549	
						d1(3,254602	0.1000000	65)=	0.7119397	
gama(l	oeta= 0.100	00000 alfa=	40) >	1.062034	30	d1(3.754602	0.1000000	65)=	0.8899247	
•	gama	beta	alfa		30	d1(4.254602	0.1000000	65)=	1.067910	
d1(1.062034	0.1000000		-7.1034052E-08		d1(4.754602	0.1000000	65)=	1.245895	
dl(1.562034	0.1000000	40)=	0.5180907		d1(5.254602	0.1000000	65)=	1.423879	
dl(2.062034	0.1000000	40)=	1.036181					05)		
						di(3 /34602	O TOOOSOO	65)=	1 601864	
			,			d1(5.754602 6.254602	0.1000000	65)=	1.601864	
dl(2.562034	0.1000000	40)=	1.554272		d1(6.254602	0.1000000	65)= 65)=	1.601864 1.779849	
d1(d1(2.562034 3.062034	0.1000000 0.1000000	40)= 40)=	1.554272 2.072362	35	d1(6.254602	0.1000000	65)=	1.779849	_
d1(d1(d1(2.562034 3.062034 3.562034	0.1000000 0.1000000 0.1000000	40)= 40)= 40)=	1.554272 2.072362 2.590453	35		6.254602 (beta= 0.10	0.1000000 00000 alfa=	65)= 70) >		
d1(d1(d1(d1(2.562034 3.062034 3.562034 4.062034	0.1000000 0.1000000 0.1000000 0.1000000	40)= 40)= 40)= 40)=	1.554272 2.072362 2.590453 3.108544	35	d1(gama(6.254602 (beta= 0.10 gama	0.1000000 00000 alfa= beta	65)= 70) > alfa	1.779849 1.364855	
d1(d1(d1(d1(d1(2.562034 3.062034 3.562034 4.062034 4.562034	0.100000 0.100000 0.100000 0.100000 0.100000	40)= 40)= 40)= 40)= 40)=	1.554272 2.072362 2.590453 3.108544 3.626635	35	d1(gama(d1(6.254602 (beta= 0.10) gama 1.364855	0.1000000 00000 alfa= beta 0.1000000	65)= 70) > alfa 70)=	1.779849 1.364855 0.0000000E+00	
d1(d1(d1(d1(d1(d1(2.562034 3.062034 3.562034 4.062034 4.562034 5.062034	0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000	40)= 40)= 40)= 40)= 40)= 40)=	1.554272 2.072362 2.590453 3.108544 3.626635 4.144725	35	d1(gama(d1(d1(6.254602 (beta= 0.10 gama 1.364855 1.864855	0.1000000 00000 alfa= beta 0.1000000 0.1000000	70) > alfa 70)= 70)= 70)=	1.779849 1.364855 0.0000000E+00 0.1287762	
d1(d1(d1(d1(d1(d1(d1(2.562034 3.062034 3.562034 4.062034 4.562034 5.062034 5.562034	0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000	40)= 40)= 40)= 40)= 40)= 40)= 40)=	1.554272 2.072362 2.590453 3.108544 3.626635 4.144725 4.662816	35	d1(gama(d1(d1(d1(6.254602 (beta= 0.10) gama 1.364855 1.864855 2.364855	0.1000000 00000 alfa= beta 0.1000000 0.1000000 0.1000000	70) > alfa 70)= 70)= 70)= 70)=	1.779849 1.364855 0.0000000E+00 0.1287762 0.2575525	
d1(d1(d1(d1(d1(d1(2.562034 3.062034 3.562034 4.062034 4.562034 5.062034	0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000	40)= 40)= 40)= 40)= 40)= 40)=	1.554272 2.072362 2.590453 3.108544 3.626635 4.144725	35	d1(gama(d1(d1(d1(d1(6.254602 (beta= 0.10) gama 1.364855 1.864855 2.364855 2.864855	0.1000000 00000 alfa= beta 0.1000000 0.1000000 0.1000000 0.1000000	70) > alfa 70)= 70)= 70)= 70)= 70)= 70)=	1.779849 1.364855 0.0000000E+00 0.1287762 0.2575525 0.3863288	
d1(2.562034 3.062034 3.562034 4.062034 5.062034 5.562034 6.062034	0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000	40)= 40)= 40)= 40)= 40)= 40)= 40)=	1.554272 2.072362 2.590453 3.108544 3.626635 4.144725 4.662816 5.180906		d1(gama(d1(d1(d1(d1(d1(6.254602 (beta= 0.10 gama 1.364855 1.864855 2.364855 2.864855 3.364855	0.1000000 00000 alfa= beta 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000	70) > alfa 70)= 70)= 70)= 70)= 70)= 70)= 70)=	1.779849 1.364855 0.0000000E+00 0.1287762 0.2575525 0.3863288 0.5151050	
d1(d1(d1(d1(d1(d1(d1(2.562034 3.062034 3.562034 4.062034 5.062034 5.562034 6.062034	0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000	40)= 40)= 40)= 40)= 40)= 40)= 40)= 45) >	1.554272 2.072362 2.590453 3.108544 3.626635 4.144725 4.662816		d1(gama(d1(d1(d1(d1(d1(d1(6.254602 (beta= 0.10 gama 1.364855 1.864855 2.364855 2.864855 3.364855 3.864855	0.1000000 00000 alfa= beta 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000	70) > alfa 70)= 70)= 70)= 70)= 70)= 70)= 70)= 70)=	1.779849 1.364855 0.0000000E+00 0.1287762 0.2575525 0.3863288 0.5151050 0.6438813	
d1(2.562034 3.062034 3.562034 4.062034 5.062034 5.562034 6.062034	0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000	40)= 40)= 40)= 40)= 40)= 40)= 40)= 45) > alfa	1.554272 2.072362 2.590453 3.108544 3.626635 4.144725 4.662816 5.180906		d1(d1(d1(d1(d1(d1(d1(d1(6.254602 (beta= 0.10 gama 1.364855 1.864855 2.364855 2.864855 3.364855 4.364855 4.364855	0.1000000 00000 alfa= beta 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000	70) > alfa 70)= 70)= 70)= 70)= 70)= 70)= 70)= 70)= 70)= 70)= 70)= 70)=	1.779849 1.364855 0.0000000E+00 0.1287762 0.2575525 0.3863288 0.5151050 0.6438813 0.7726575	
d1(d1(d1(d1(d1(d1(d1(d1(d1(d1(2.562034 3.062034 4.062034 4.062034 5.062034 5.562034 6.062034 Deta= 0.100 gama 1.082358	0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000	40)= 40)= 40)= 40)= 40)= 40)= 40)= 45) > alfa 45)=	1.554272 2.072362 2.590453 3.108544 3.626635 4.144725 4.662816 5.180906 1.082358 0.0000000E+00		d1(d1(d1(d1(d1(d1(d1(d1(d1(6.254602 (beta= 0.10 gama 1.364855 1.864855 2.364855 2.864855 3.364855 4.364855 4.364855 4.864855	0.1000000 00000 alfa= beta 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000	70) >= 70) = 70 = 70 = 70 = 70 = 70 = 70 = 70 = 70 = 70 = 70 =	1.779849 1.364855 0.0000000E+00 0.1287762 0.2575525 0.3863288 0.5151050 0.6438813 0.7726575 0.9014338	
d1(d1(d1(d1(d1(d1(d1(d1(d1(d1(2.562034 3.062034 3.562034 4.062034 4.562034 5.062034 5.562034 6.062034 Deta= 0.100 gama 1.082358 1.582358	0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000	40)= 40)= 40)= 40)= 40)= 40)= 40)= 45) > alfa 45)= 45)=	1.554272 2.072362 2.590453 3.108544 3.626635 4.144725 4.662816 5.180906 1.082358 0.0000000E+00 0.4292893		d1(d1(d1(d1(d1(d1(d1(d1(d1(d1(6.254602 (beta= 0.10 gama 1.364855 1.864855 2.364855 3.364855 3.864855 4.364855 4.364855 5.364855 5.364855	0.1000000 00000 alfa= beta 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000 0.1000000	70) >= 70) = 70 = 70 = 70 = 70 = 70 = 70 = 70 = 70 = 70 = 70 = 70 =	1.779849 1.364855 0.000000E+00 0.1287762 0.2575525 0.3863288 0.5151050 0.6438813 0.7726575 0.9014338 1.030210	_
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d1(2.562034 3.062034 3.562034 4.062034 4.562034 5.562034 5.562034 6.062034 beta= 0.100 gama 1.082358 1.582358 2.082358 2.582358 3.082358 4.082358 5.082358 6.082358 6.082358 5.10813 1.608113 2.108113 2.608113 3.108113 4.108113 5.108113 5.108113 5.108113 5.608113 5.108113 5.108113 5.108113 5.108113 5.108113 5.108113 5.108113 5.108113 5.108113 5.108113	0.1000000 0.1000000	40	1.554272 2.072362 2.590453 3.108544 3.626635 4.144725 4.662816 5.180906 1.082358 0.0000000E+00 0.4292893 0.8585786 1.287868 1.717157 2.146446 2.575736 3.005025 3.434314 3.863604 4.292893 1.108113 0.0000000E+00 0.3542794 0.7085589 1.062838 1.417118 1.771397 2.125677 2.479956 2.834235 3.188515	40 45 50 55	d1(6.254602 (beta= 0.10 gama 1.364855 1.864855 2.364855 2.364855 3.364855 4.364855 4.364855 5.364855 5.364855 5.364855 6.364855 6.364855 beta= 0.100 gama 1.587469 2.087469 3.087469 4.587469 4.587469 5.587469 6.087469 6.587469 beta= 0.100 gama 2.316863 2.816863 3.316863 4.316863 4.316863	0.1000000 00000 alfa= beta 0.1000000	65)= 70) > alfa 70)= 70)= 70)= 70)= 70)= 70)= 70)= 70)= 70)= 70)= 70)= 75) > alfa 75)= 75)= 75)= 75)= 75)= 75)= 75)= 75)= 80) > alfa 80)= 80)= 80)= 80)= 80)= 80)= 80)=	1.779849 1.364855 0.0000000E+00 0.1287762 0.2575525 0.3863288 0.5151050 0.6438813 0.7726575 0.9014338 1.030210 1.158986 1.287763 1.587469 0.0000000E+00 8.2210816E-02 0.1644216 0.2466324 0.3288433 0.4110541 0.4932648 0.5754756 0.6576865 0.7398973 0.8221080 2.316863 -1.0509909E-08 3.7392177E-02 7.4784376E-02 0.1121766 0.1495687 0.1869609	
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d1(2.562034 3.062034 3.562034 4.062034 4.562034 5.562034 5.562034 6.062034 beta= 0.100 gama 1.082358 1.582358 2.082358 2.582358 3.082358 4.082358 5.082358 6.082358 6.082358 5.10813 1.608113 2.108113 2.608113 3.108113 4.108113 5.108113 5.108113 5.108113 5.608113 5.108113 5.108113 5.108113 5.108113 5.108113 5.108113 5.108113 5.108113 5.108113 5.108113	0.1000000 0.1000000	40	1.554272 2.072362 2.590453 3.108544 3.626635 4.144725 4.662816 5.180906 1.082358 0.00000000E+00 0.4292893 0.8585786 1.287868 1.717157 2.146446 2.575736 3.005025 3.434314 3.863604 4.292893 1.108113 0.0000000E+00 0.3542794 0.7085589 1.062838 1.417118 1.771397 2.125677 2.479956 2.834235 3.188515 3.542794	40 45 50 55	d1(6.254602 (beta= 0.10 gama 1.364855 1.864855 2.364855 2.364855 3.364855 4.364855 4.364855 5.364855 5.364855 5.364855 6.364855 6.364855 beta= 0.100 gama 1.587469 2.087469 3.087469 4.587469 4.587469 5.587469 6.087469 6.587469 beta= 0.100 gama 2.316863 2.816863 3.316863 4.316863 4.316863	0.1000000 00000 alfa= beta 0.1000000	65)= 70) > alfa 70)= 70)= 70)= 70)= 70)= 70)= 70)= 70)= 70)= 70)= 70)= 75) > alfa 75)= 75)= 75)= 75)= 75)= 75)= 75)= 75)= 80) > alfa 80)= 80)= 80)= 80)= 80)= 80)= 80)=	1.779849 1.364855 0.0000000E+00 0.1287762 0.2575525 0.3863288 0.5151050 0.6438813 0.7726575 0.9014338 1.030210 1.158986 1.287763 1.587469 0.0000000E+00 8.2210816E-02 0.1644216 0.2466324 0.3288433 0.4110541 0.4932648 0.5754756 0.6576865 0.7398973 0.8221080 2.316863 -1.0509909E-08 3.7392177E-02 7.4784376E-02 0.1121766 0.1495687 0.1869609	

TABLE 1-continued

TABLE 1-continued

	Design Para	meters for CSS	C Tube Fittin	g, $(d1=\Delta L/R\epsilon_p)$.			Design Para	meters for CSS	C Tube Fitting	g, $(d1=\Delta L/R\epsilon_p)$.
d1(6.816863	0.1000000	80)=	0.3365296	 5	d1(2.075072	0.2000000	30)=	1.332051
d1(7.316863	0.1000000	80)=		3	d1(2.575072	0.2000000	30)=	1.998076
<u>ur(</u>	7.510005	0.100000	00)=	0.5757210		d1(3.075072	0.2000000	30)=	2.664102
gama(heta- 0.20	00000 alfa=	5) >	1.001908		d1(3.575072	0.2000000	30)= 30)=	3.330127
Burra(gama	beta	alfa	1.001700		d1(4.075072	0.2000000	30)=	3.996153
d1(1.001908	0.2000000	ana 5)=	0.0000000E+00		d1(4.575072	0.2000000	30)=	4.662178
d1(1.501908	0.2000000	5)=	4.567655					30)=	
d1(2.001908	0.2000000	5)=		10	d1(5.075072	0.2000000		5.328203
dl(2.501908	0.2000000	3)= 5)=	9.135310 13.70297		d1(5.575072	0.2000000	30)= 30)=	5.994229
	3.001908		,			d 1(6.075072	0.2000000	30 <u>)</u> =	6.660254
d1(0.2000000		18.27062			1	00000 -10-	25) -	1.10/271
d1(3.501908	0.2000000		22,83828		gama(00000 alfa=	35) >	1.106271
d1(4.001908	0.2000000	5)=	27.40593			gama	beta	alfa	
d1(4.501908	0.2000000	5)=	31.97359	15	d1(1.106271	0.2000000	35)=	0.0000000E+00
dl(5.001908	0.2000000	5)=	36.54124		d1(1.606271	0.2000000	35)=	0.5397293
d1(5.501908	0.2000000	5)=	41.10890		d 1(2.106271	0.2000000	35)=	1.079459
d1(6.001908	0.2000000	5)=	45.67656		d1(2.606271	0.2000000	35)=	1.619188
						d1(3.106271	0.2000000	35)=	2.158918
gama(i		00000 alfa=	10) >	1.007684		d1(3.606271	0.2000000	35)=	2.698647
	gama	beta	alfa			d1(4.106271	0.2000000	35)≃	3.238376
d1(1.007684	0.2000000	10)=	0.0000000E+00	20	d1(4.606271	0.2000000	35)=	3.778105
d1(1.507684	0.2000000	10)≔	2.259764		d1(5.106271	0.2000000	35)=	4.317834
d1(2.007684	0.2000000	10)=	4.519529		d1(5.606271	0.2000000	35)=	4.857564
d1(2.507684	0.2000000	10)=	6.779292		d1(6.106271	0.2000000	35)=	5.397293
d1(3.007684	0.2000000	10)=	9.039058					<u> </u>	
d1(3.507684	0.2000000	10)=	11.29882		gama(beta= 0.20	00000 alfa=	40) >	1.145987
d1(4.007684	0.2000000	10)=	13.55858	25	8	gama	beta	alfa	
d1(4.507684	0.2000000	10)=	15.81835	3	d1(1.145987	0.2000000	40)=	0.0000000E+00
d1(5.007684	0.2000000	10)=	18.07811		dl(1.645987	0.2000000	40)=	0.4403043
d1(5.507684	0.2000000	10)=	20.33787		d1(2.145987	0.2000000	40)=	0.8806087
d1(6.007684	0.2000000	10)=	22.59764		d1(2.645987	0.2000000	40)=	1.320913
	0.007001	0.200000	10 ,-	22.59701		d1(3.145987	0.2000000	40)=	1.761218
gama(t	neta 0.200	00000 alfa=	15) >	1.017492		d1(3.645987	0.2000000	40)=	2.201522
Samm()	gama 0.200	beta	alfa	1.017472	30	d1(4.145987	0.2000000	40)=	2.641827
d1(1.017492	0.2000000	15)=	0.0000000E+00			4.645987		40)=	
	1.517492		15)=	1.479655		d1(0.2000000		3.082131
d1(d1(2.017492	0.2000000 0.2000000	15)=	2.959310		d1(d1(5.145987 5.645987	0.2000000	40)= 40)=	3.522435 3.962740
d1(2.517492		15)=					0.2000000		
d1(0.2000000		4.438965		d1(6.145987	0.2000000	40)=	4.403044
	3.017492	0.2000000	15)=	5.918621	35		L 0.200	00000 -16-	45) -	1 107107
d1(3.517492	0.2000000	15)≔	7.398275	35	gama(00000 alfa=		1.197197
d1(d1(3.517492 4.017492	0.2000000 0.2000000	15)= 15)=	7.398275 8.877931	35		gama	beta	alfa	
d1(d1(d1(3.517492 4.017492 4.517492	0.2000000 0.2000000 0.2000000	15)= 15)= 15)=	7.398275 8.877931 10.35759	35	d1(gama 1.197197	beta 0.2000000	alfa 45)=	0.0000000E+00
d1(d1(d1(d1(3.517492 4.017492 4.517492 5.017492	0.2000000 0.2000000 0.2000000 0.2000000	15)= 15)= 15)= 15)=	7.398275 8.877931 10.35759 11.83724	35	d1(d1(gama 1.197197 1.697197	beta 0.2000000 0.2000000	alfa 45)= 45)=	0.000000E+00 0.3585786
d1(d1(d1(d1(d1(3.517492 4.017492 4.517492 5.017492 5.517492	0.200000 0.2000000 0.2000000 0.2000000 0.2000000	15)= 15)= 15)= 15)= 15)=	7.398275 8.877931 10.35759 11.83724 13.31690	35	d1(d1(d1(gama 1.197197 1.697197 2.197197	beta 0.2000000 0.2000000 0.2000000	alfa 45)= 45)= 45)=	0.0000000E+00 0.3585786 0.7171574
d1(d1(d1(d1(d1(3.517492 4.017492 4.517492 5.017492	0.2000000 0.2000000 0.2000000 0.2000000	15)= 15)= 15)= 15)=	7.398275 8.877931 10.35759 11.83724		d1(d1(d1(d1(gama 1.197197 1.697197 2.197197 2.697197	beta 0.2000000 0.2000000 0.2000000 0.2000000	alfa 45)= 45)= 45)= 45)=	0.0000000E+00 0.3585786 0.7171574 1.075736
d1(d1(d1(d1(d1(d1(3.517492 4.017492 4.517492 5.017492 5.517492 6.017492	0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000	15)= 15)= 15)= 15)= 15)= 15)=	7.398275 8.877931 10.35759 11.83724 13.31690 14.79655	35 40	d1(d1(d1(d1(d1(gama 1.197197 1.697197 2.197197 2.697197 3.197197	beta 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000	alfa 45)= 45)= 45)= 45)= 45)=	0.0000000E+00 0.3585786 0.7171574 1.075736 1.434315
d1(d1(d1(d1(d1(d1(3.517492 4.017492 4.517492 5.017492 5.517492 6.017492 Deta= 0.200	0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000	15)= 15)= 15)= 15)= 15)= 15)= 20) >	7.398275 8.877931 10.35759 11.83724 13.31690		d1(d1(d1(d1(d1(d1(gama 1.197197 1.697197 2.197197 2.697197 3.197197 3.697197	beta 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000	alfa 45)= 45)= 45)= 45)= 45)= 45)= 45)=	0.000000E+00 0.3585786 0.7171574 1.075736 1.434315 1.792893
d1(d1(d1(d1(d1(d1(gama(t	3.517492 4.017492 4.517492 5.017492 5.517492 6.017492 Deta= 0.200 gama	0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000	15)= 15)= 15)= 15)= 15)= 15)= 20) > alfa	7.398275 8.877931 10.35759 11.83724 13.31690 14.79655		d1(d1(d1(d1(d1(d1(d1(gama 1.197197 1.697197 2.197197 2.697197 3.197197 3.697197 4.197197	beta 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000	alfa 45)= 45)= 45)= 45)= 45)= 45)= 45)= 45)=	0.0000000E+00 0.3585786 0.7171574 1.075736 1.434315 1.792893 2.151472
d1(d1(d1(d1(d1(d1(gama(t)	3.517492 4.017492 4.517492 5.017492 5.517492 6.017492 Deta= 0.200 gama 1.031629	0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000	15)= 15)= 15)= 15)= 15)= 15)= 20) > alfa 20)=	7.398275 8.877931 10.35759 11.83724 13.31690 14.79655 1.031629 0.0000000E+00		d1(d1(d1(d1(d1(d1(d1(d1(gama 1.197197 1.697197 2.197197 2.697197 3.197197 4.197197 4.697197	beta 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000	alfa 45)= 45)= 45)= 45)= 45)= 45)= 45)= 45)= 45)=	0.0000000E+00 0.3585786 0.7171574 1.075736 1.434315 1.792893 2.151472 2.510051
d1(d1(d1(d1(d1(d1(d1(d1(d1(3.517492 4.017492 4.517492 5.017492 5.517492 6.017492 Deta= 0.200 gama 1.031629 1.531629	0.200000 0.200000 0.200000 0.200000 0.200000 0.200000 0.200000 0.200000 0.2000000	15)= 15)= 15)= 15)= 15)= 20) > alfa 20)= 20)=	7.398275 8.877931 10.35759 11.83724 13.31690 14.79655 1.031629 0.0000000E+00 1.081358		d1(d1(d1(d1(d1(d1(d1(d1(gama 1.197197 1.697197 2.197197 2.697197 3.197197 3.697197 4.197197 4.697197 5.197197	beta 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000	alfa 45)= 45)= 45)= 45)= 45)= 45)= 45)= 45)= 45)= 45)=	0.0000000E+00 0.3585786 0.7171574 1.075736 1.434315 1.792893 2.151472 2.510051 2.868629
d1(3.517492 4.017492 4.517492 5.017492 5.517492 6.017492 Deta= 0.200 gama 1.031629 1.531629 2.031629	0.200000 0.200000 0.200000 0.200000 0.200000 0.200000 0.200000 0.200000 0.200000 0.2000000 0.2000000	15)= 15)= 15)= 15)= 15)= 20) > alfa 20)= 20)= 20)=	7.398275 8.877931 10.35759 11.83724 13.31690 14.79655 1.031629 0.0000000E+00 1.081358 2.162717	40	d1(d1(d1(d1(d1(d1(d1(d1(d1(gama 1.197197 1.697197 2.197197 2.697197 3.197197 3.697197 4.197197 4.697197 5.697197	beta 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000	alfa 45)= 45)= 45)= 45)= 45)= 45)= 45)= 45)= 45)= 45)= 45)=	0.000000E+00 0.3585786 0.7171574 1.075736 1.434315 1.792893 2.151472 2.510051 2.868629 3.227208
d1(3.517492 4.017492 4.517492 5.017492 5.517492 6.017492 Deta= 0.200 gama 1.031629 1.531629 2.031629 2.531629	0.200000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000	15)= 15)= 15)= 15)= 15)= 15)= 20) > alfa 20)= 20)= 20)= 20)=	7.398275 8.877931 10.35759 11.83724 13.31690 14.79655 1.031629 0.0000000E+00 1.081358 2.162717 3.244075		d1(d1(d1(d1(d1(d1(d1(d1(gama 1.197197 1.697197 2.197197 2.697197 3.197197 3.697197 4.197197 4.697197 5.197197	beta 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000	alfa 45)= 45)= 45)= 45)= 45)= 45)= 45)= 45)= 45)= 45)=	0.0000000E+00 0.3585786 0.7171574 1.075736 1.434315 1.792893 2.151472 2.510051 2.868629
d1(3.517492 4.017492 4.517492 5.017492 5.517492 6.017492 Deta= 0.200 gama 1.031629 1.531629 2.031629 2.531629 3.031629	0.200000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000	15)= 15)= 15)= 15)= 15)= 20) > alfa 20)= 20)= 20)= 20)= 20)=	7.398275 8.877931 10.35759 11.83724 13.31690 14.79655 1.031629 0.0000000E+00 1.081358 2.162717 3.244075 4.325433	40	d1(d1(d1(d1(d1(d1(d1(d1(d1(d1(gama 1.197197 1.697197 2.197197 2.697197 3.197197 3.697197 4.197197 4.697197 5.697197 6.197197	beta 0.200000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000	alfa 45)= 45)= 45)= 45)= 45)= 45)= 45)= 45)= 45)= 45)= 45)=	0.000000E+00 0.3585786 0.7171574 1.075736 1.434315 1.792893 2.151472 2.510051 2.868629 3.227208 3.585786
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TΔ	.BI	F	1-continue	А

TABLE 1-continued

	Design Para	meters for CSS	C Tube Fitting, (d1=ΔL/R	ε _p).		Design Para	meters for CSS	C Tube Fitting	g, (d1= Δ L/R ϵ_p).	
d1(5.859236	0,2000000	55)= 2.05223		d1(2.013210	0.3000000	10)=	3.943652	
d1(6.359236	0.2000000	55)= 2.28026	3	d1(2.513210	0.3000000	10)=	5.915477	
					d1(3.013210	0.3000000	10)=	7.887302	
gama(t	oeta= 0.20	00000 alfa=	60) > 1.500000		d1(3.513210	0.3000000	10)=	9.859128	
	gama	beta	alfa		d1(4.013210	0.3000000	10)=	11.83095	
d1(1.500000	0.2000000	60)= 0.0000000		d1(4.513210	0.3000000	10)=	13.80278	
dl(2.000000	0.2000000	60)= 0.173205		d1(5.013210	0.3000000	10)=	15.77460	
d1(2.500000	0.2000000	60)= 0.346410		d1(5.513210	0.3000000	10)=	17.74643	
d1(3.000000	0.2000000	60)= 0.519615		d1(6.013210	0.3000000	10)=	19.71825	
d1(3.500000	0.2000000	60)= 0.692820			(5-4- 0.20)	00000 -15-	16) -	1.020170	
d1(4.000000	0.2000000	60)= 0.866025 60)= 1.03923		gama		00000 alfa=		1.030178	
dl(4.500000	0.2000000	60)= 1.03923 60)= 1.21243		417	gama 1.030178	beta 0.3000000	alfa 15)=	0.0000000E+00	
d1(d1(5.000000 5.500000	0,2000000 0,2000000	60)= 1.38564		d1(d1(1.530178	0.3000000	15)= 15)≈	1.286470	
dl(6.000000	0.2000000	60)= 1.55884		d1(2.030178	0.3000000	15)=	2.572940	
d1(6.500000	0.2000000	60)= 1.73205		d1(2.530178	0.3000000	15)=	3.859410	
<u> </u>	0.500000	0.200000	00)= 1:73203		d1(3.030178	0.3000000	15)=	5.145880	
gama(t	eta= 0.20	00000 alfa=	65) > 1.737939		d1(3.530178	0.3000000	15)=	6.432350	
B(-	gama	beta	alfa		d1(4.030178	0.3000000	15)=	7.718821	
d1(1.737939	0.2000000	65)= 0.0000000	E+00 20	dl(4.530178	0.3000000	15) =	9.005290	
d1(2.237939	0.2000000	65)= 0.122816		d1(5.030178	0.3000000	15)=	10.29176	
d1(2.737939	0.2000000	65)= 0.245632	1	d1(5.530178	0.3000000	15)=	11.57823	
d1(3.237939	0.2000000	65)= 0.368448	1	d1(6.030178	0.3000000	15)=	12.86470	
d1(3.737939	0.2000000	65)= 0.491264	2						 .
d1(4.237939	0.2000000	65)= 0.614080		gama	(beta= 0.30)	00000 alfa=		1.054860	
d1(4.737939	0.2000000	65)= 0.736896			gama	beta	alfa		
d1(5.237939	0.2000000	65)= 0.859712		d1(1.054860	0.3000000	20)=	0.0000000E+00	
d1(5.737939	0.2000000	65)= 0.982528		d1(1.554860	0.3000000	20)=	0.9351683	
d1(6.237939	0.2000000	65)= 1.10534		d1(2.054860	0.3000000	20)=	1.870337	
dI(6.737939	0.2000000	65)= 1.22816	1	d1(2.554860	0.3000000	20)=	2.805505	
	. 0.00	20000 15	50) 0.042515		d1(3.054860	0.3000000	20)=	3.740673	
gama(t		00000 alfa=	70) > 2.243517	30	d1(3.554860	0.3000000	20)=	4.675841	
317	gama	beta	alfa 70)= 0.0000000	E : 00	d1(4.054860	0.3000000	20)=	5.611008	
d1(2.243517	0.2000000	,		d1(4.554860	0.3000000	20)= 20)=	6.546177	
d1(2.743517	0.2000000 0.2000000	70)= 7.5567380 70)= 0.151134		d1(d1(5.054860	0.3000000 0.3000000	20)=	7.481345 8.416512	
d1(d1(3.243517 3.743517	0.2000000	70)= 0.131134		d1(5.554860 6.054860	0.3000000	20)=	9.351681	
			10)- 0.220102		uit	0.054000	0.5000000	20)-	7.331001	
	4 243517	0.2000000	70 \- 0.302269	4						
d1(d1(4.243517 4.743517	0.2000000	70)= 0.302269 70)= 0.377836	4 35	gamai		00000 alfa=	25) >	1 088374	
d1(4.743517	0.2000000	70)= 0.377836	4 8 35	gama	(beta= 0.30	00000 alfa=		1.088374	
d1(d1(4.743517 5.243517	0.2000000 0.2000000	70)= 0.377836 70)= 0.453404	4 8 1	•	(beta= 0.30) gama	beta	alfa		
d1(d1(d1(4.743517 5.243517 5.743517	0.2000000 0.2000000 0.2000000	70)= 0.377836 70)= 0.453404 70)= 0.528971	4 8 1 5	d1((beta= 0.30) gama 1.088374	beta 0.3000000	alfa 25)≃	0.0000000E+00	
d1(d1(d1(d1(4.743517 5.243517	0.2000000 0.2000000	70)= 0.377836 70)= 0.453404 70)= 0.528971	4 35 1 5 8	•	(beta= 0.300 gama 1.088374 1.588374	beta	alfa		
d1(d1(d1(4.743517 5.243517 5.743517 6.243517	0.2000000 0.2000000 0.2000000 0.2000000	70)= 0.377836 70)= 0.453404 70)= 0.528971 70)= 0.604538	4 35 1 5 8 2 5	d1(d1((beta= 0.30) gama 1.088374	beta 0.3000000 0.3000000	alfa 25)≃ 25)=	0.0000000E+00 0.7173234	
d1(d1(d1(d1(d1(4.743517 5.243517 5.743517 6.243517 6.743517	0.2000000 0.2000000 0.2000000 0.2000000 0.2000000	70)= 0.377836 70)= 0.453404 70)= 0.528971 70)= 0.604538 70)= 0.680106	4 35 1 5 8 2	d1(d1(d1((beta= 0.300 gama 1.088374 1.588374 2.088374	beta 0.3000000 0.3000000 0.3000000	alfa 25)= 25)= 25)=	0.0000000E+00 0.7173234 1.434647	
d1(d1(d1(d1(d1(4.743517 5.243517 5.743517 6.243517 6.743517 7.243517	0.2000000 0.2000000 0.2000000 0.2000000 0.2000000	70)= 0.377836 70)= 0.453404 70)= 0.528971 70)= 0.604538 70)= 0.680106 70)= 0.755673	4 35 1 5 8 2 5	d1(d1(d1(d1(d1(d1((beta= 0.300 gama 1.088374 1.588374 2.088374 3.588374 3.588374 3.588374	beta 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000	alfa 25)= 25)= 25)= 25)= 25)= 25)= 25)=	0.0000000E+00 0.7173234 1.434647 2.151970 2.869293 3.586617	
d1(d1(d1(d1(d1(d1(4.743517 5.243517 5.743517 6.243517 6.743517 7.243517	0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000	70)= 0.377836 70)= 0.453404 70)= 0.528971 70)= 0.604538 70)= 0.680106 70)= 0.755673 75) > 4.172484 alfa	4 8 35 1 1 1 5 8 8 2 2 5 40	d1(d1(d1(d1(d1(d1(d1((beta= 0.300 gama 1.088374 1.588374 2.088374 2.588374 3.588374 3.588374 4.088374	beta 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000	alfa 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)=	0.0000000E+00 0.7173234 1.434647 2.151970 2.869293 3.586617 4.303940	
d1(d1(d1(d1(d1(gama(b	4.743517 5.243517 5.743517 6.243517 6.743517 7.243517 oeta= 0.200 gama 4.172484	0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000	70)= 0.377836 70)= 0.453404 70)= 0.528971 70)= 0.660106 70)= 0.680106 70)= 0.755673. 75) > 4.172484 alfa 75)= 0.0000000	4 35 1 1 1 5 8 8 2 2 5 40 E÷00	d1(d1(d1(d1(d1(d1(d1(d1((beta= 0.30) gama 1.088374 1.588374 2.088374 2.588374 3.088374 4.088374 4.588374	beta 0.300000 0.300000 0.300000 0.300000 0.300000 0.300000 0.3000000 0.3000000 0.3000000	alfa 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)=	0.0000000E+00 0.7173234 1.434647 2.151970 2.869293 3.586617 4.303940 5.021263	
d1(d1(d1(d1(d1(gama(b)	4.743517 5.243517 5.743517 6.243517 6.743517 7.243517 0.cta= 0.200 gama 4.172484 4.672484	0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000	70)= 0.377836 70)= 0.453404 70)= 0.528971. 70)= 0.604538 70)= 0.680106 70)= 0.755673. 75) > 4.172484 alfa 75)= 0.0000000 75)= 3.0446989.	4 35 8 1 5 5 8 2 2 5 — 40 E+00 E-02	d1(d1(d1(d1(d1(d1(d1(d1((beta= 0.30) gama 1.088374 1.588374 2.088374 2.588374 3.088374 4.088374 4.588374 5.088374	beta 0.300000 0.300000 0.300000 0.300000 0.300000 0.300000 0.300000 0.300000 0.300000	alfa 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)=	0.000000E+00 0.7173234 1.434647 2.151970 2.869293 3.586617 4.303940 5.021263 5.738586	
d1(d1(d1(d1(d1(d1(d1(d1(d1(d1(4.743517 5.243517 5.743517 6.243517 6.243517 7.243517 7.243517 	0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000	70)= 0.377836 70)= 0.453404 70)= 0.528971 70)= 0.604538 70)= 0.680106 70)= 0.755673. 75) > 4.172484 alfa 75)= 0.0000000 75)= 3.0446989 75)= 6.0893979	4 35 8 1 5 5 8 8 2 2 5 40 E+00 E-02 E-02	d1(d1(d1(d1(d1(d1(d1(d1(d1((beta= 0.300 gama 1.088374 1.588374 2.088374 2.588374 3.088374 3.588374 4.588374 4.588374 5.588374	beta 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000	alfa 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)=	0.000000E+00 0.7173234 1.434647 2.151970 2.869293 3.586617 4.303940 5.021263 5.738586 6.455910	
d1(d1(d1(d1(d1(d1(d1(d1(d1(d1(4.743517 5.243517 5.743517 6.243517 6.743517 7.243517 0.200 gama 4.172484 5.172484 5.672484	0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000	70)= 0.377836 70)= 0.453404 70)= 0.528971 70)= 0.604538 70)= 0.680106 70)= 0.755673 75) > 4.172484 alfa 75)= 0.0000000 75)= 0.0000000 75)= 6.0893979 75)= 9.1340967	4 8 35 1 1 5 8 8 2 2 5 40 E+00 E-02 E-02 45	d1(d1(d1(d1(d1(d1(d1(d1((beta= 0.30) gama 1.088374 1.588374 2.088374 2.588374 3.088374 4.088374 4.588374 5.088374	beta 0.300000 0.300000 0.300000 0.300000 0.300000 0.300000 0.300000 0.300000 0.300000	alfa 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)=	0.000000E+00 0.7173234 1.434647 2.151970 2.869293 3.586617 4.303940 5.021263 5.738586	
d1(4.743517 5.243517 5.743517 6.243517 6.743517 7.243517 	0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000	70)= 0.377836 70)= 0.453404 70)= 0.528971 70)= 0.660138 70)= 0.680106 70)= 0.755673 75) > 4.172484 alfa 75)= 0.0000000 75)= 3.0446989 75)= 6.0893979 75)= 9.1340967 75)= 9.1340967 75)= 0.121788	4 8 35 1 1 5 8 8 2 2 5 40 40 E+00 E-02 E-02 45 0	d1(d1(d1(d1(d1(d1(d1(d1(d1(d1((beta= 0.300 gama 1.088374 1.588374 2.088374 2.588374 3.588374 4.088374 4.588374 5.588374 6.088374	beta 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000	alfa 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)=	0.000000E+00 0.7173234 1.434647 2.151970 2.869293 3.586617 4.303940 5.021263 5.738586 6.455910 7.173233	
d1(4.743517 5.243517 5.243517 6.243517 6.743517 7.243517 0.200 gama 4.172484 4.672484 5.672484 6.172484 6.672484 6.672484	0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000	70)= 0.377836 70)= 0.453404 70)= 0.528971 70)= 0.680106 70)= 0.680106 70)= 0.755673 75) > 4.172484 alfa 75)= 0.0000000 75)= 3.0446989 75)= 6.0893979 75)= 9.1340967 75)= 9.1340967 75)= 0.152234	4 8 35 1 1 1 5 8 8 2 2 5 40 40 E+00 E-02 E-02 45 0 9	d1(d1(d1(d1(d1(d1(d1(d1(d1(d1((beta= 0.300 gama 1.088374 1.588374 2.088374 2.588374 3.588374 4.088374 4.588374 5.588374 6.088374 (beta= 0.300	beta 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000	alfa 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 30) >	0.000000E+00 0.7173234 1.434647 2.151970 2.869293 3.586617 4.303940 5.021263 5.738586 6.455910	
d1(4.743517 5.243517 5.243517 6.243517 6.243517 7.243517 7.243517 0.201 gama 4.172484 4.672484 5.172484 6.172484 6.672484 7.172484	0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000	70)= 0.377836 70)= 0.453404 70)= 0.528971. 70)= 0.604538 70)= 0.680106 70)= 0.755673. 75) > 4.172484 alfa 75)= 0.0000000 75)= 3.0446989. 75)= 6.0893979 75)= 9.1340967. 75)= 0.121788 75)= 0.121788 75)= 0.182681	4 35 1 5 5 8 8 2 2 5 40 40 E+00 E-02 E-02 E-02 45 0 9 9	d1(d1(d1(d1(d1(d1(d1(d1(d1(d1((beta= 0.300 gama 1.088374 1.588374 2.088374 2.588374 3.088374 4.088374 4.088374 5.588374 5.588374 6.088374 (beta= 0.300 gama	beta 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000	alfa 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 30) > alfa	0.0000000E+00 0.7173234 1.434647 2.151970 2.869293 3.586617 4.303940 5.021263 5.738586 6.455910 7.173233	
d1(4.743517 5.243517 5.743517 6.243517 6.243517 7.243517 7.243517 7.243517 0.200 gama 4.172484 5.672484 5.672484 6.672484 7.172484 7.672484 7.672484	0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000	70)= 0.377836 70)= 0.453404 70)= 0.528971 70)= 0.604538 70)= 0.680106 70)= 0.755673. 75) > 4.172484 alfa 75)= 0.0000000 75)= 3.0446989 75)= 6.0893979 75)= 9.1340967 75)= 0.121788 75)= 0.121788 75)= 0.125234 75)= 0.182681 75)= 0.182681 75)= 0.213128	48 35 1 1 5 88 2 2 5 40 E+00 E-02 E-02 45 0 9 9 9	d1(d1(d1(d1(d1(d1(d1(d1(d1(d1((beta= 0.300 gama 1.088374 1.588374 2.088374 2.588374 3.088374 4.088374 4.588374 4.588374 5.588374 6.088374 (beta= 0.300 gama 1.132503	beta 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000	alfa 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 30) > alfa 30)=	0.000000E+00 0.7173234 1.434647 2.151970 2.869293 3.586617 4.303940 5.021263 5.738586 6.455910 7.173233 1.132503 0.0000000E+00	
d1(4.743517 5.243517 5.743517 6.243517 6.243517 7.243517 	0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000 0.2000000	70)= 0.377836 70)= 0.453404 70)= 0.453404 70)= 0.528971 70)= 0.680106 70)= 0.755673 75) > 4.172484 alfa 75)= 0.0000000 75)= 3.0446989 75)= 6.0893979 75)= 9.1340967 75)= 0.121788 75)= 0.152234 75)= 0.182681 75)= 0.182681 75)= 0.243575	48 35 1 1 5 88 2 2 5 40 E+00 E=-02 E-02 E-02 45 0 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9 9	d1(d1(d1(d1(d1(d1(d1(d1(d1(d1((beta= 0.300 gama 1.088374 1.588374 2.088374 2.588374 3.588374 4.588374 4.588374 4.588374 6.088374 (beta= 0.300 gama 1.132503 1.632503	beta 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000 0.3000000	alfa 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 30) > alfa 30)= 30)=	0.000000E+00 0.7173234 1.434647 2.151970 2.869293 3.586617 4.303940 5.021263 5.738586 6.455910 7.173233 1.132503 0.0000000E+00 0.5660253	
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TABLE 1-continued

TABLE 1-continued

1		Design Para	meters for CSS	C Tube Fittir	ıg, (d1=ΔL/Rε _p).			Design Para	meters for CSS	C Tube Fittin	g, (d1=ΔL/Rε _p).
Banachetar 0.3000000 alije 40 > 1.26596S 40 C 5.096856 0.3000000 65 > 0.3053238 40 C 5.096856 0.3000000 65 > 0.40583238 40 C 5.096856 0.3000000 65 > 0.40583239 40 C 5.096856 0.3000000 65 > 0.4058329 40 C 5.096856 40 C							d1(0.3000000		0.1352943
	d 1(6.190112	0.3000000	35)=	4.525570		d1(0.3000000	65)=	0.2029415
Main Company Delta Main Main Company Compa							d 1(5.009636	0.3000000	65)=	0.2705886
all (1.759968	gama(l	oeta= 0.30	00000 alfa=		1.265968		d1(5.509636	0.3000000	65)=	0.3382358
di							d1(6.009636	0.3000000	65)=	0.4058830
di (2.26598	d1(1.265968	0.3000000		0.0000000E+00		d1(6.509636	0.3000000	65)=	0.4735300
dil (2.25898	d1(1.765968	0.3000000	40)=	0.3625183	10	d1(7.009636	0.3000000	65)=	0.5411772
A	d1(2.265968	0.3000000	40)=	0.7250366	10	d1(7.509636	0.3000000	65)=	0.6088244
A	d1(2.765968	0.3000000								
did 3.76598	d1(3.265968	0.3000000								
di(4.26596							gama	(beta= 0.30)	00000 alfa=	70) >	7 304273
did 4.765968							Burra			,	1.50 1215
dl(d1(U UUUUUUUE+UU
dil						15					
dil (6.285968							•				
Beams Deliver Display Displ											
gamma	u.i.(0.203906	0.300000	40)=	3.023163						
Second S	~~~~(1	0.20	00000 -16-	15) -	1.200454						
dl(gama(i				1.306434						
dil (1.868454 0.3000000 45)= 0.2876860	31.6				0.00000000	20					
dil(2.368454 0.3000000 45)= 0.5757360 dil(11.30427 0.3000000 70)= 0.20126262 dil(3.368454 0.3000000 45)= 1.151472 dil(3.368454 0.3000000 45)= 1.151472 dil(4.368454 0.3000000 45)= 1.1757208 dil(4.368454 0.3000000 45)= 2.215976 dil(5.368494 0.3000000 45)= 2.215976 dil(5.368494 0.3000000 45)= 2.230944 dil(5.368494 0.3000000 45)= 2.230944 dil(5.368494 0.3000000 45)= 2.230944 dil(5.368494 0.3000000 0 45)= 2.2309812 dil(6.368494 0.3000000 0 45)= 2.2309812 dil(6.368494 0.3000000 0 45)= 2.2378680 dil(6.368494 0.3000000 0 45)= 2.2378680 dil(6.368494 0.3000000 0 45)= 2.2378680 dil(6.368494 0.3000000 0 45)= 0.00000000000000000000000000000000 dil(6.3684954 0.3000000 0 50)= 0.000000000000000000000000000000000						20					
dit 2.868454 0.3000000											
dit 3.368454 0.3000000											
Ali							d1(12.30427	0.3000000	70)=	0.2235847
dI(4.368454 0.3000000	-										
dI(gama	(beta= 0.400	00000 alfa=	5) >	1.005096
dI(5.368454 0.3000000 45)= 2.590812 dI(6.368454 0.3000000 45)= 2.590812 dI(6.368454 0.3000000 45)= 2.878680 dI(2.003966 0.4000000 5)= 6.464058 dI(3.003966 0.4000000 5)= 6.464058 dI(3.003966 0.4000000 5)= 6.464058 dI(3.003976 0.4000000 5)= 0.0000000000000 dI(3.003976 0.4000000 5)= 0.00000000000000 dI(3.003976 0.4000000 5)= 0.0000000000000000 dI(3.003976 0.4000000 5)= 0.00000000000000000 dI(3.003976 0.4000000 0 5)= 0.000000000000000 dI(3.003976 0.4000000 0 5)= 0.00000000000000000 dI(3.003976 0.4000000 0 5)= 0.00000000000000000 dI(3.003976 0.4000000 0 5)= 0.0000000000000000 dI(3.003976 0.4000000 0 5)= 0.000000000000000000 dI(3.003976 0.4000000 dI(3.003976 0.4000000 0 5)= 0.000000000000000000 dI(3.003976 0.4000000 dI(3.003976 0.40000000 dI(3.003976 0.40000000 dI(3.003976 0.40000000						25		gama	beta	alfa	
di(d1(0.0000000E+00
dif	d1(5.368454	0.3000000	45)=	` 2.302944		d1(1.505096	0.4000000	5)=	3.420284
Sama(beta 0.3000000 afa 50 > 1.513575 30 30 30 30 30 30 30 3	d1(5.868454	0.3000000	45)=	2.590812		d1(2.005096	0.4000000	5)=	6.840568
	d1(6.368454	0.3000000	45)≕	2.878680		d1(2.505096	0.4000000	5)=	10.26085
							d1(3.005096			
Suma Deta alfa d1 1.513575 0.3000000 50 = 0.00000000E+00 d1 4.550906 0.4000000 5 = 2.334199 d1 2.513575 0.3000000 50 = 0.474775 d1 5.550906 0.4000000 5 = 2.334199 d1 4.550906 0.4000000 5 = 2.334199 d1 5.550906 0.4000000 5 = 2.334199 d1 5.550906 0.4000000 5 = 30.78255 d1 5.550906 0.4000000 d1 = 10.0000000000000000000000000000000000	gama(b	eta= 0.30	00000 alfa=	50) >	1.513575	30		3.505096			
d1	•					30				5)=	
A	d1(0.0000000E+00						
d1(2.513575 0.3000000 50)= 0.4474775											
d1(3.013575 0.3000000 50											
A											
d1											
d1(35	gama(beta= 0.400	00000 alfa≃	10) >	1.020625
d1(5.013576 0.3000000 50)= 1.566171							6				-10-00-0
Color							d1(0.0000000E+00
al(6.013576 0.3000000 50 ≥ 2.013649 41 d1(2.020625 0.4000000 10 > 3.67775 al(6.513576 0.3000000 50 > 2.237387 40 d1(2.50025 0.4000000 10 > 5.051661 gama(beta= 0.3000000 alfa d1(3.500625 0.4000000 10 > 6.735548 d1(1.735820 0.3000000 55 > 0.0000000E+00 d1(4.520625 0.4000000 10 > 10.10332 d1(2.235820 0.3000000 55 > 0.3339752 d1(4.520625 0.400000 10 > 11.78721 d1(3.235820 0.3000000 55 > 0.3339752 d1(4.520625 0.400000 10 > 11.515498 d1(3.235820 0.3000000 55 > 0.8349380 45 d1(6.026520 0.400000 10 > 15.15488 d1(5.735820 0.3000000 55 > 1.669936 d1(1.629320											
A											
gama(beta= 0.3000000 alfa= 55) > 1.735820 dl(3.520625 0.4000000 10)= 8.419435 dl(4.020625 0.4000000 10)= 10.10332 dl(4.020625 0.4000000 10)= 11.78721 dl(4.020625 0.4000000 10)= 10.0000000 dl(2.735820 0.3000000 55)= 0.1669876 dl(5.020625 0.4000000 10)= 11.78721 dl(5.020625 0.4000000 10)= 10.0000000 dl(3.235820 0.3000000 55)= 0.5009628 dl(3.735820 0.3000000 55)= 0.6679505 dl(4.235820 0.3000000 55)= 0.06679505 dl(4.235820 0.3000000 55)= 1.001926 dl(5.735820 0.3000000 55)= 1.001926 dl(5.735820 0.3000000 55)= 1.168913 dl(6.235820 0.3000000 55)= 1.502888 dl(6.235820 0.3000000 55)= 1.502888 dl(6.235820 0.3000000 55)= 1.669876 dl(6.735820 0.3000000 55)= 1.609876 dl(6.735820 0.3000000 55)= 1.609876 dl(6.235820 0.3000000 55)= 1.609876 dl(6.473474 0.4000000 15)= 0.90000000 dl(6.2000000 dl(6.20000000000000000000000 dl(6.2000000000000000000000000000000000000											
gama(beta= 0.3000000 alfa= 55) > 1.735820						40					
Sama	gama(h	eta= 0.30	00000 alfa=	55) >	1.735820						
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$					-1102020						
d1(2.235820 0.3000000 55 ⇒ 0.1669876 d1(5.026625 0.4000000 10 ⇒ 13.47109 d1(2.235820 0.3000000 55 ⇒ 0.5009628 45 d1(6.020625 0.4000000 10 ⇒ 15.15498 d1(5.235820 0.3000000 55 ⇒ 0.6679505 d1(6.0235820 0.3000000 55 ⇒ 0.6679505 d1(6.0235820 0.3000000 55 ⇒ 0.6679505 d1(6.235820 0.3000000 55 ⇒ 0.6679505 d1(6.235820 0.3000000 55 ⇒ 1.01891 d1(1.047347 0.4000000 15 ⇒ 0.00000000 15 ⇒ 0.000000000 15 ⇒ 0.0000000000 15 ⇒ 1.097387 d1(1.047347 0.4000000 15 ⇒ 2.186569 d1(1.047347 0.4000000 15 ⇒ 2.186569 d1(1.047347 0.4000000 15 ⇒ 2.198566 </td <td>41(</td> <td></td> <td></td> <td></td> <td>0.0000000E±00</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>	41(0.0000000E±00						
d1(2.735820 0.3000000 55 ⇒ 0.3339752 d1(5.520625 0.4000000 10 ⇒ 15.15498 d1(3.235820 0.3000000 55 ⇒ 0.6679505 ⇒ 61(4.235820 0.3000000 55 ⇒ 0.6679505 ⇒ alfa d1(4.735820 0.3000000 55 ⇒ 0.6679505 ⇒ agama (beta= 0.4000000 alfa d1(3.235820 0.3000000 55 ⇒ 1.001926 ¬ gama (beta= 0.4000000 15 ⇒ 0.0000000e+00 d1(1.573820 0.3000000 55 ⇒ 1.353901 d1(1.573820 0.3000000 55 ⇒ 1.502888 50 d1(2.47347 0.4000000 15 ⇒ 2.186569 d1(6.735820 0.3000000 60 ⇒ 0.169876 d1(2.47347 0.400000 15 ⇒ 2.186569 d1(2.125000 0.3000000 60 ⇒ <td< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></td<>											
d1(3.235820 0.3000000 55 ⇒ 0.5009628 45 d1(6.020625 0.4000000 10 ⇒ 16.83887 d1(3.735820 0.3000000 55 ⇒ 0.6679505 gama (beta= 0.4000000 alfa 15) > 1.047347 d1(4.735820 0.3000000 55 ⇒ 1.168913 d1(1.047347 0.4000000 15 ⇒ 0.00000000±00 d1(5.235820 0.3000000 55 ⇒ 1.168913 d1(1.547347 0.4000000 15 ⇒ 0.00000000±00 d1(6.235820 0.3000000 55 ⇒ 1.502888 50 d1(2.047347 0.4000000 15 ⇒ 2.186569 d1(6.735820 0.3000000 55 ⇒ 1.5669876 d1(2.047347 0.4000000 15 ⇒ 2.186569 d1(2.125000 3000000 60 ⇒ 0.1250000 3.0300000 60 ⇒											
d1(3.735820 0.3000000 55 ⇒ 0.6679505 d1(4.235820 0.3000000 55 ⇒ 0.8349380 gama(beta= 0.4000000 alfa= 15) > 1.047347 d1(4.735820 0.3000000 55 ⇒ 1.168913 d1(1.647347 0.4000000 15 ⇒ 0.000000E+00 d1(5.735820 0.3000000 55 ⇒ 1.502888 50 d1(1.547347 0.4000000 15 ⇒ 0.0000000E+00 d1(6.235820 0.3000000 55 ⇒ 1.502888 50 d1(2.047347 0.4000000 15 ⇒ 1.093285 d1(6.735820 0.3000000 55 ⇒ 1.502888 50 d1(2.547347 0.4000000 15 ⇒ 2.186569 d1(6.735820 0.3000000 alfa= d1(2.547347 0.4000000 15 ⇒ 2.186569 d1(2.125000 3.000000 d16 ⇒ 0.3000000 60 ⇒ 0.1154701 5 41(2.547347 0.4000000 15 </td <td></td> <td></td> <td></td> <td></td> <td></td> <td>15</td> <td></td> <td></td> <td></td> <td></td> <td></td>						15					
d1(4.235820 0.3000000 55)= 0.8349380						43	urt	0.020023	0.400000	10)-	10.63667
d1(4.735820 0.3000000 55)= 1.001926 gama beta alfa d1(5.235820 0.3000000 55)= 1.168913 d1(1.047347 0.4000000 15)= 0.0000000E+00 d1(5.735820 0.3000000 55)= 1.502888 50 d1(2.047347 0.4000000 15)= 2.186569 d1(6.735820 0.3000000 55)= 1.669876 d1(2.047347 0.4000000 15)= 2.186569 d1(6.735820 0.3000000 alfa 60) > 2.125000 d1(2.547347 0.4000000 15)= 3.279854 d1(2.125000 0.3000000 60)= 0.00000000E+00 d1(4.547347 0.4000000 15)= 5.5466424 d1(2.125000 0.3000000 60)= 0.01154701 55 d1(5.547347 0.4000000 15)=							~omo(hoto- 0.400	00000 alfa-	15) >	1.047247
d1(5.235820 0.3000000 55)= 1.168913 d1(1.047347 0.4000000 15)= 0.0000000E+00 d1(5.735820 0.3000000 55)= 1.335901 d1(1.547347 0.4000000 15)= 1.093285 d1(6.235820 0.3000000 55)= 1.669876 d1(2.547347 0.4000000 15)= 2.186569 d1(6.735820 0.3000000 55)= 1.669876 d1(2.547347 0.4000000 15)= 2.186569 d1(6.735820 0.3000000 alfa 60 > 2.125000 d1(2.547347 0.4000000 15)= 3.279854 d1(2.125000 0.3000000 60)= 0.0000000E+00 d1(4.647347 0.4000000 15)= 5.466424 d1(3.125000 0.3000000 60)= 0.2309401 55 d1(5.547347							gama				1.04/34/
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$							417				0.000000077.00
d1(6.235820 0.3000000 55)= 1.502888 50 d1(2.047347 0.4000000 15)= 2.186569 d1(6.735820 0.3000000 55)= 1.669876 d1(2.047347 0.4000000 15)= 3.279854 gama(beta= 0.3000000 alfa 60) > 2.125000 d1(3.047347 0.4000000 15)= 5.379854 d1(2.125000 0.3000000 60)= 0.00000000E+00 d1(4.047347 0.4000000 15)= 5.466424 d1(2.125000 0.3000000 60)= 0.1154701 55 d1(4.547347 0.4000000 15)= 6.559709 d1(3.125000 0.3000000 60)= 0.1154701 55 d1(5.547347 0.4000000 15)= 8.746278 d1(4.125000 0.3000000 60)= 0.35773503 d1(6.047347 <td></td> <td></td> <td></td> <td>•</td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td> <td></td>				•							
d1(6.735820 0.3000000 55)= 1.669876 d1(2.547347 0.4000000 15)= 3.279854 gama(beta= 0.3000000 alfa 60) > 2.125000 d1(3.547347 0.4000000 15)= 4.373139 d1(2.125000 0.3000000 60)= 0.0000000E+00 d1(3.547347 0.4000000 15)= 5.466424 d1(2.125000 0.3000000 60)= 0.0000000E+00 d1(4.647347 0.4000000 15)= 5.466424 d1(2.125000 0.3000000 60)= 0.1154701 55 d1(5.47347 0.4000000 15)= 6.559709 d1(3.125000 0.3000000 60)= 0.2309401 41 5.547347 0.4000000 15)= 8.746278 d1(4.125000 0.3000000 60)= 0.4618802 d1(5.647347 0.4000000 <t< td=""><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></t<>											
Sama						50					
gama(beta= 0.3000000 alfa= 60) > 2.125000 d1(3.547347 0.4000000 15)= 5.466424 gama beta alfa d1(2.125000 0.3000000 60)= 0.0000000E+00 d1(4.647347 0.4000000 15)= 6.559709 d1(2.125000 0.3000000 60)= 0.0000000E+00 d1(4.547347 0.4000000 15)= 6.559709 d1(3.125000 0.3000000 60)= 0.1154701 55 d1(5.047347 0.4000000 15)= 7.652993 d1(3.125000 0.3000000 60)= 0.2309401 55 d1(5.547347 0.4000000 15)= 8.746278 d1(4.125000 0.3000000 60)= 0.4618802 d1(6.047347 0.4000000 15)= 9.839563 d1(5.625000 0.3000000 60)= 0.8082904 <th< td=""><td>u1(</td><td>0.753820</td><td>0.5000000</td><td><i>3</i>3 <i>)</i>=</td><td>1.0098/0</td><td></td><td></td><td></td><td></td><td></td><td></td></th<>	u1(0.753820	0.5000000	<i>3</i> 3 <i>)</i> =	1.0098/0						
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$		0.00	20000 10	(0) -	2.125000						
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	gama(b				2.125000						
$\begin{array}{cccccccccccccccccccccccccccccccccccc$	11.6				0.00000000					•	
$\begin{array}{cccccccccccccccccccccccccccccccccccc$											
d1(3.125000 0.3000000 60)= 0.230401 d1(3.547347 0.4000000 15)= 9.895953 d1(3.625000 0.3000000 60)= 0.3464102 d1(6.047347 0.4000000 15)= 10.93285 d1(4.625000 0.3000000 60)= 0.5773503 gama(beta= 0.4000000 alfa 20) > 1.086700 d1(5.125000 0.3000000 60)= 0.6928203 gama beta alfa d1(6.125000 0.3000000 60)= 0.8082904 d1(1.086700 0.4000000 20)= 0.0000000E+00 d1(6.625000 0.3000000 60)= 0.8082904 d1(1.086700 0.4000000 20)= 0.7889779 d1(6.625000 0.3000000 60)= 1.039231 d1(2.086700 0.4000000 20)= 1.577956 d1(7.125000 0.3000000 60)= 1.154701 d1(2.586700 <td></td> <td></td> <td></td> <td></td> <td></td> <td>55</td> <td></td> <td></td> <td></td> <td></td> <td></td>						55					
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$						33					
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$					0.3464102		d1(6.047347	0.4000000	15)=	10.93285
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$					0.4618802						
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	d1(60)=	0.5773503		gama(beta= 0.400	00000 alfa=	20) >	1.086700
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$	dl(5.125000	0.3000000	60)=	0.6928203		,				
$\begin{array}{cccccccccccccccccccccccccccccccccccc$							d1(0.0000000E+00
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$						60					
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$											
$\begin{array}{c ccccccccccccccccccccccccccccccccccc$											
$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$				/-							
$\begin{array}{cccccccccccccccccccccccccccccccccccc$		-1- 0.20/	00000 alfa=	65) >	3 009636						
$ d1(\begin{tabular}{lllllllllllllllllllllllllllllllllll$	gama(h	era= II 🕶			00,000						
	gama(b						417	4 กิริธ์ธัดด	() AINNNES	70 V	4 733867
0.311023 0.3000000 03 /- 0.704717142-02 u1(3.000037 0.4000000 20)= 0.311023		gama	beta	alfa	0.0000000E±00	65					
	dl(gama 3.009636	beta 0.3000000	alfa 65)=		65	d1(4.586699	0.4000000	20)=	5.522845

TABLE 1-continued

TABLE 1-continued

		IABLE I		·				171000	-commueu		
	Design Para	meters for CSS	C Tube Fittin	g, (d1=ΔL/Rε _p).			Design Para	meters for CSS	C Tube Fitting	g, (d1= $\Delta L/R\epsilon_p$).	
d1(d1(5.586699 6.086699	0.4000000 0.4000000	20)= 20)≈	7.100801 7.889779	5	d1(d1(2.966811 3.466811 3.966811	0.4000000 0.4000000	50)= 50)= 50)=	0.3169367 0.4754050	
gama(neta= 0.40	00000 alfa=	25) >	1.141105		d1(d1(4.466811	0.4000000 0.4000000	50)=	0.6338733 0.7923417	
Barria	gama	beta	alfa	1.1 11105		d1(4.966811	0.4000000	50)=	0.9508100	
d1(1.141105	0.4000000	25)=	0.0000000E+00		d1(5.466811	0.4000000	50)=	1.109279	
d1(1.641105	0.4000000	25)=	0.5990134	10	d1(5.966811	0.4000000	50)=	1.267747	
d1(2.141105	0.4000000	25)=	1.198027		d1(6.466811	0.4000000	50)=	1.426215	
d1(2.641105	0.4000000	25)≃	1.797040		d1(6.966811	0.4000000	50)=	1.584683	
d1(3.141105	0.4000000	25)= 25)=	2.396053		gama(L-ta- 0.400	00000 alfa-	55) >	2546216	
d1(d1(3.641105 4.141105	0.4000000 0.4000000	25)=	2.995066 3.594079		gama(gama 0.400	00000 alfa= beta	alfa	2.546316	
dl(4.641105	0.4000000	25)=	4.193092		d1(2.546316	0.4000000	ana 55)=	0.0000000E+00	
dl(5.141105	0.4000000	25)=	4.792106	15	d1(3.046316	0.4000000	55)=	0.1059489	
dl(5.641105	0.4000000	25)=	5.391119		d1(3.546316	0.4000000	55)=	0.2118977	
d1(6.141105	0.4000000	25)=	5.990132		d1(4.046316	0.4000000	55)=	0.3178467	
			20)			d1(4.546316	0.4000000	55)=	0.4237956	
gama(00000 alfa=	30) >	1.214581		d1(5.046316	0.4000000	55)=	0.5297443	
417	gama 1.214581	beta 0.4000000	alfa 30)=	0.0000000E+00	20	d1(d1(5.546316 6.046316	0.4000000 0.4000000	55)= 55)=	0.6356933 0.7416422	
d1(d1(1.714581	0.4000000	30)=	0.4660254	-*	d1(6.546316	0.4000000	55)=	0.8475911	
dl(2.214581	0.4000000	30)=	0.9320508		d1(7.046316	0.4000000	55)=	0.9535400	
d1(2.714581	0.4000000	30)≃	1.398076		d1(7.546316	0.4000000	55)=	1.059489	
d1(3.214581	0.4000000	30)=	1.864102							
d1(3.714581	0.4000000	30)=	2.330127		gama(00000 alfa=		4.000001	
d1(4.214581	0.4000000	30)=	2.796153	25		gama	beta	alfa		
d1(4.714581	0.4000000	30)=	3.262178		d1(4.000001	0.4000000	60)=	0.0000000E+00	
dl(5.214581	0.4000000	30)= 30)=	3.728203		d1(4.500001	0.4000000	60)= 60)≃	5.7735037E-02	
dl(dl(5.714581 6.214581	0.4000000 0.4000000	30)=	4.194229 4.660254		d1(d1(5.000001 5.500001	0.4000000 0.4000000	60)=	0.1154700 0.1732050	
<u>ui(</u>	0.214501	0.4000000	30 /-	4.0002J+		d1(6.000001	0.4000000	60)=	0.2309400	
gama(l	oeta= 0.40	00000 alfa=	35) >	1.313958	30	d1(6.500001	0.4000000	60)=	0.2886750	
	gama	beta	alfa		50	d1(7.000001	0.4000000	60)=	0.3464100	
d1(1.313958	0.4000000	35)=	0.0000000E+00		d1(7.500001	0.4000000	60)=	0.4041451	
dl(1.813958	0.4000000	35)=	0.3653848		d1(8.000002	0.4000000	60)=	0.4618801	
d1(2.313958	0.4000000	35)=	0.7307695		d1(8.500002	0.4000000	60)=	0.5196151	
d1(2.813958	0.4000000	35)=	1.096154						0.5773501	
.11/	2 212050					d1(9.000002	0.4000000	60)=	0.0770001	
d1(3.313958	0.4000000	35)=	1.461539	35						_
d1(3.813958	0.4000000 0.4000000	35)= 35)=	1.461539 1.826923	35	gama(beta= 0.400	00000 alfa=	65) >	15.52622	
d1(d1(3.813958 4.313958	0.4000000 0.4000000 0.4000000	35)= 35)= 35)=	1.461539 1.826923 2.192308	35	gama(beta= 0.400 gama	00000 alfa= beta	65) > alfa	15.52622	
d1(3.813958	0.4000000 0.4000000	35)= 35)=	1.461539 1.826923	35		beta= 0.400	00000 alfa= beta 0.4000000	65) >		
d1(d1(d1(3.813958 4.313958 4.813958	0.400000 0.400000 0.400000 0.400000	35)= 35)= 35)= 35)= 35)= 35)=	1.461539 1.826923 2.192308 2.557693	35	gama(beta= 0.400 gama 15.52622	00000 alfa= beta	65) > alfa 65)=	15.52622 0.0000000E+00	
d1(d1(d1(d1(3.813958 4.313958 4.813958 5.313958	0.400000 0.400000 0.400000 0.400000 0.400000	35)= 35)= 35)= 35)= 35)=	1.461539 1.826923 2.192308 2.557693 2.923077		gama(d1(d1(d1(d1(beta= 0.400 gama 15.52622 16.02622 16.52622 17.02622	00000 alfa= beta 0.4000000 0.4000000 0.4000000 0.4000000	65) > alfa 65)= 65)= 65)= 65)=	15.52622 0.0000000E+00 1.2478273E-02 2.4956491E-02 3.7434764E-02	
d1(d1(d1(d1(d1(d1(3.813958 4.313958 4.813958 5.313958 5.813958 6.313958	0.400000 0.400000 0.400000 0.400000 0.400000 0.400000 0.400000	35)= 35)= 35)= 35)= 35)= 35)= 35)=	1.461539 1.826923 2.192308 2.557693 2.923077 3.288462 3.653847	35	gama(d1(d1(d1(d1(d1(beta= 0.400 gama 15.52622 16.02622 16.52622 17.02622 17.52622	00000 alfa= beta 0.4000000 0.4000000 0.4000000 0.4000000 0.4000000	65) > alfa 65)= 65)= 65)= 65)= 65)=	15.52622 0.0000000E+00 1.2478273E-02 2.4956491E-02 3.7434764E-02 4.9912982E-02	
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d1(3.813958 4.313958 4.313958 4.313958 5.313958 5.313958 5.813958 6.313958 5.813958 6.313958 5.813958 6.313958 5.813958 6.313958 5.813958 6.313958 5.813958 6.313958 6.313958 6.313958 6.313958 6.451504 6.451504 6.451504 6.451504 6.451504 6.451504 6.451504 6.451504 6.451504 6.51239 6.651239 6.651239 6.651239 6.651239 6.651239 6.651239 6.651239 6.651239	0.400000 0.4000000 0.4000000 0.4000000 0.4000000 0.4000000 0.4000000	35 =	1.461539 1.826923 2.192308 2.557693 2.923077 3.288462 3.653847 1.451504 0.0000000E+00 0.2847320 0.5594641 0.8541961 1.138928 1.423660 1.708392 1.993124 2.277856 2.562588 2.847321 1.651239 0.0000000E+00 0.2171572 0.4343146 0.6514719 0.8686291 1.085786 1.302943 1.520101 1.737258 1.954415 2.171573	40 45 50 55	gama(d1(d1(d1(d1(d1(d1(d1(d1(d1(d1	beta= 0.400 gama 15.52622 16.02622 17.02622 17.02622 17.52622 18.02622 18.52622 19.02622 20.02622 20.02622 20.52622 beta= 0.500 gama 1.007654 2.507654 2.007654 3.007654 4.507654 5.007654 5.507654 6.007654 beta= 0.500 gama 1.031099 1.531099 2.031099 3.031099 3.031099 3.031099 3.031099	beta 0.400000 0.4000000 0.4000000 0.4000000 0.4000000 0.4000000 0.4000000 0.4000000 0.4000000 0.4000000 0.4000000 0.4000000 0.5000000	65) > alfa 65	15.52622 0.0000000E+00 1.2478273E-02 2.4956491E-02 3.7434764E-02 4.9912982E-02 6.2391199E-02 7.4869417E-02 8.7347694E-02 9.9825911E-02 0.1123041 0.1247824 1.007654 0.0000000E+00 2.846598 5.693197 8.539796 11.38639 14.23299 17.07959 19.92619 22.77279 25.61938 28.46598 1.031099 0.0000000E+00 1.395948 2.791897 4.187845 5.583793 6.979742	

TABLE 1-continued

TABLE 1-continued

	Design Para	meters for CSS	C Tube Fittin	g, (d1= $\Delta L/R\epsilon_p$).			Design Para	meters for CSS	C Tube Fitting	g, (d1= Δ L/R ϵ _p).
d1(5.531099	0.5000000	10)=	12.56354		d1(2.776517	0.5000000	40)=	0.4138919
d1(6.031099	0.5000000	10)=	13.95948		d1(3.276517	0.5000000	40)=	0.6208376
						d1(3.776517	0.5000000	40)=	0.8277834
gama(b	eta= 0.50	00000 alfa=	15) >	1.071886		d1(4.276517	0.5000000	40)=	1.034729
	gama	beta	alfa			d1(4.776517	0.5000000	40)=	1.241675
d1(1.071886	0.5000000	15)=	0.0000000E+00		d1(5.276517	0.5000000	40)=	1.448621
d1(1.571886	0.5000000	15)=	0.9000998	10	d1(5.776517	0.5000000	40)=	1.655567
d1(2.071886	0.5000000	15)=	1.800200	10	d1(6.276517	0.5000000	40)=	1.862513
d1(2.571886	0.5000000	15)=	2.700299		d1(6.776517	0.5000000	40)=	2.069459
d1(3.071886	0.5000000	15)=	3.600399						
dl(3.571886	0.5000000	15)=	4.500498		gama(heta= 0.500	00000 alfa=	45) >	2.207107
d1(4.071886	0.5000000	15)=	5.400597		8	gama	beta	alfa	2.201.407
d1(4.571886	0.5000000	15)=	6.300696		d1(2.207107	0.5000000	45)=	0.0000000E+00
dl(5.071886	0.5000000	15)=	7.200796	15	dl(2.707107	0.5000000	45)=	0.1464467
d1(5.571886	0.5000000	15)=	8.100896			3.207107			0.2928933
		0.5000000	15)=			dl(0.5000000	45)=	
dl(6.071886	0.3000000	13)=	9.000996		dl(3.707107	0.5000000	45)=	0.4393399
	. 0.50	00000 10	20)	1 100000		d1(4.207107	0.5000000	45)=	0.5857866
gama(b		00000 alfa=	20) >	1.133022		d1(4.707107	0.5000000	45)=	0.7322332
•••	gama	beta	alfa		20	d1(5.207107	0.5000000	45)=	0.8786799
d1(1.133022	0.5000000	20)=	0.0000000E+00	20	d1(5.707107	0.5000000	45)=	1.025126
d1(1.633022	0.5000000	20)=	0.6427878		d1(6.207107	0.5000000	45)=	1.171573
d1(2.133022	0.5000000	20)=	1.285576		d1(6.707107	0.5000000	45)=	1.318020
d1(2.633022	0.5000000	20)=	1.928363		d1(7.207107	0.5000000	45)=	1.464466
d1(3.133022	0.5000000	20)=	2.571151					·····	
d1(3.633022	0.5000000	20)=	3.213938		gama(beta= 0.500	00000 alfa=	50) >	3.054885
d1(4.133022	0.5000000	20)=	3.856726	25		gama	beta	alfa	
d1(4.633022	0.5000000	20)=	4.499513		d1(3.054885	0.5000000	50)≕	0.0000000E+00
d1(5.133022	0.5000000	20)==	5.142301		d1(3.554885	0.5000000	50)=	9.3198024E-02
d1(5.633022	0.5000000	20)=	5.785089		d1(4.054885	0.5000000	50)=	0.1863960
d1(6.133022	0.5000000	20)=	6.427876		d1(4.554885	0.5000000	50)=	0.2795941
	0.100022		20)	0.127070		d1(5.054885	0.5000000	50)=	0.3727920
gama(b	eta- 0.50	00000 alfa=	25) >	1.219792		d1(5.554885	0.5000000	50)=	0.4659900
garia(0	gama 0.50	beta	alfa	1.217172	30	d1(6.054885	0.5000000	50)=	0.5591879
417				0.0000000E+00						
d1(1.219792	0.5000000	25)=	0.0000000E+00		d1(6.554885	0.5000000		0.6523860
d1(1.719792	0.5000000	25)=	0.4807031		d1(7.054885	0.5000000	50)=	0.7455839
d1(2.219792	0.5000000	25)=	0.9614062		d1(7.554885	0.5000000	50)=	0.8387819
dI(2.719792	0.5000000	25)=	1.442109		d1(8.054885	0.5000000	50)=	0.9319797
d1(3.219792	0.5000000	25)=	1.922812	35					
d1(3.719792	0.5000000	25)=	2.403515	35	gama(00000 alfa=		5.559950
d1(d1(3.719792 4.219792	0.5000000 0.5000000	25)= 25)=	2.403515 2.884219	35		gama	beta	alfa	
d1(d1(d1(3.719792 4.219792 4.719792	0.5000000 0.5000000 0.5000000	25)= 25)= 25)=	2.403515 2.884219 3.364922	35	d1(gama 5.559950	beta 0.5000000	alfa 55)=	0.0000000E+00
d1(d1(d1(d1(3.719792 4.219792 4.719792 5.219792	0.5000000 0.5000000 0.5000000 0.5000000	25)= 25)= 25)= 25)=	2.403515 2.884219 3.364922 3.845624	35	d1(d1(gama 5.559950 6.059950	beta 0.5000000 0.5000000	alfa 55)= 55)=	0.0000000E+00 4.4910204E-02
d1(d1(d1(d1(d1(3.719792 4.219792 4.719792 5.219792 5.719792	0.5000000 0.5000000 0.5000000 0.5000000 0.5000000	25)= 25)= 25)= 25)= 25)=	2.403515 2.884219 3.364922 3.845624 4.326327	35	d1(d1(d1(gama 5.559950 6.059950 6.559950	beta 0.5000000 0.5000000 0.5000000	alfa 55)= 55)= 55)=	0.0000000E+00
d1(d1(d1(d1(3.719792 4.219792 4.719792 5.219792	0.5000000 0.5000000 0.5000000 0.5000000	25)= 25)= 25)= 25)=	2.403515 2.884219 3.364922 3.845624		d1(d1(d1(d1(gama 5.559950 6.059950 6.559950 7.059950	beta 0.5000000 0.5000000 0.5000000 0.5000000	alfa 55)= 55)= 55)= 55)=	0.0000000E+00 4.4910204E-02 8.9820325E-02 0.1347304
d1(d1(d1(d1(d1(3.719792 4.219792 4.719792 5.219792 5.719792 6.219792	0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000	25)= 25)= 25)= 25)= 25)= 25)=	2.403515 2.884219 3.364922 3.845624 4.326327 4.807031	35 40	d1(d1(d1(gama 5.559950 6.059950 6.559950 7.059950 7.559950	beta 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000	alfa 55)= 55)= 55)= 55)= 55)=	0.0000000E+00 4.4910204E-02 8.9820325E-02
d1(d1(d1(d1(d1(3.719792 4.219792 4.719792 5.219792 5.719792 6.219792	0.5000000 0.5000000 0.5000000 0.5000000 0.5000000	25)= 25)= 25)= 25)= 25)= 25)= 30) >	2.403515 2.884219 3.364922 3.845624 4.326327		d1(d1(d1(d1(gama 5.559950 6.059950 6.559950 7.059950	beta 0.5000000 0.5000000 0.5000000 0.5000000	alfa 55)= 55)= 55)= 55)= 55)= 55)=	0.0000000E+00 4.4910204E-02 8.9820325E-02 0.1347304
d1(d1(d1(d1(d1(3.719792 4.219792 4.719792 5.219792 5.719792 6.219792	0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000	25)= 25)= 25)= 25)= 25)= 25)= 30) > alfa	2.403515 2.884219 3.364922 3.845624 4.326327 4.807031		d1(d1(d1(d1(d1(gama 5.559950 6.059950 6.559950 7.059950 7.559950	beta 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000	alfa 55)= 55)= 55)= 55)= 55)=	0.0000000E+00 4.4910204E-02 8.9820325E-02 0.1347304 0.1796406
d1(d1(d1(d1(d1(3.719792 4.219792 4.719792 5.219792 5.719792 6.219792 eta= 0.500	0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000	25)= 25)= 25)= 25)= 25)= 25)= 30) >	2.403515 2.884219 3.364922 3.845624 4.326327 4.807031		d1(d1(d1(d1(d1(d1(gama 5.559950 6.059950 6.559950 7.059950 7.559950 8.059951	beta 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000	alfa 55)= 55)= 55)= 55)= 55)= 55)=	0.000000E+00 4.4910204E-02 8.9820325E-02 0.1347304 0.1796406 0.2245508
d1(d1(d1(d1(d1(d1(gama(b	3.719792 4.219792 4.719792 5.219792 5.719792 6.219792 eta= 0.500 gama	0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000	25)= 25)= 25)= 25)= 25)= 25)= 30) > alfa	2.403515 2.884219 3.364922 3.845624 4.326327 4.807031 1.341506		d1(d1(d1(d1(d1(d1(d1(gama 5.559950 6.059950 6.559950 7.059950 7.559950 8.059951 8.559951	beta 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000	alfa 55)= 55)= 55)= 55)= 55)= 55)= 55)=	0.000000E+00 4.4910204E-02 8.9820325E-02 0.1347304 0.1796406 0.2245508 0.2694609
d1(d1(d1(d1(d1(d1(gama(b)	3.719792 4.219792 4.719792 5.219792 5.719792 6.219792 eta= 0.500 gama 1.341506	0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000	25)= 25)= 25)= 25)= 25)= 25)= 30) > alfa 30)=	2.403515 2.884219 3.364922 3.845624 4.326327 4.807031 1.341506 0.0000000E+00		d1(d1(d1(d1(d1(d1(d1(d1(gama 5.559950 6.059950 6.559950 7.059950 7.559950 8.059951 8.559951	beta 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000	alfa 55)= 55)= 55)= 55)= 55)= 55)= 55)=	0.000000E+00 4.4910204E-02 8.9820325E-02 0.1347304 0.1796406 0.2245508 0.2694609 0.3143710
d1(d1(d1(d1(d1(d1(gama(b)	3.719792 4.219792 4.719792 5.219792 5.719792 6.219792 eta= 0.500 gama 1.341506 1.841506	0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000	25)= 25)= 25)= 25)= 25)= 25)= 30) > alfa 30)= 30)=	2.403515 2.884219 3.364922 3.845624 4.326327 4.807031 1.341506 0.0000000E+00 0.3660255		d1(d1(d1(d1(d1(d1(d1(d1(gama 5.559950 6.059950 6.559950 7.059950 7.559950 8.059951 8.559951 9.059951 9.559951	beta 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000	alfa 55)= 55)= 55)= 55)= 55)= 55)= 55)= 55)=	0.0000000E+00 4.4910204E-02 8.9820325E-02 0.1347304 0.1796406 0.2245508 0.2694609 0.3143710 0.3592812
d1(d1(d1(d1(d1(d1(d1(d1(d1(d1(3.719792 4.219792 4.719792 5.219792 5.719792 6.219792 eta= 0.500 gama 1.341506 1.841506 2.341506	0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000	25)= 25)= 25)= 25)= 25)= 25)= 30) > 31 alfa 30)= 30)= 30)=	2.403515 2.884219 3.364922 3.845624 4.326327 4.807031 1.341506 0.0000000E+00 0.3660255 0.7320511	40	d1(d1(d1(d1(d1(d1(d1(d1(d1(gama 5.559950 6.059950 6.559950 7.059950 7.559950 8.059951 9.059951 9.559951 10.05995	beta 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000	alfa 55)= 55)= 55)= 55)= 55)= 55)= 55)= 55)= 55)= 55)= 55)=	0.0000000E+00 4.4910204E-02 8.9820325E-02 0.1347304 0.1796406 0.2245508 0.2694609 0.3143710 0.3592812 0.4041913
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d1(d1(d1(d1(d1(d1(d1(d1(d1(d1(3.719792 4.219792 4.719792 5.219792 5.219792 6.219792 eta= 0.500 gama 1.341506 1.841506 2.341506 2.341506 3.341506	0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000	25)= 25)= 25)= 25)= 25)= 25)= 30) > 31	2.403515 2.884219 3.364922 3.845624 4.326327 4.807031 1.341506 0.0000000E+00 0.3660255 0.7320511 1.098076 1.464102	40	d1(d1(d1(d1(d1(d1(d1(d1(d1(gama 5.559950 6.059950 6.559950 7.059950 7.559950 8.059951 9.059951 9.559951 10.05995 10.55995	beta 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000	alfa 55)= 55)= 55)= 55)= 55)= 55)= 55)= 55)= 55)= 55)=	0.000000E+00 4.4910204E-02 8.9820325E-02 0.1347304 0.1796406 0.2245508 0.2694609 0.3143710 0.3592812 0.4041913 0.4491014
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d1(3.719792 4.219792 4.719792 5.219792 5.219792 6.219792 eta= 0.500 gama 1.341506 1.841506 2.341506 2.341506 3.341506 4.341506 4.341506 6.341506 6.341506 6.341506 eta= 0.500 gama 1.515412 2.015413 3.015413 3.015413 3.015413 4.015412 4.5155412 5.015412 5.515412 6.015412 6.515412 6.515412	0.5000000 0.5000000	25 = 25 = 25 = 25 = 25 = 25 = 25 = 25 = 25 = 25 = 30 = 30 = 30 = 30 = 30 = 30 = 30 = 30 = 30 = 30 = 35 =	2.403515 2.884219 3.364922 3.845624 4.326327 4.807031 1.341506 0.0000000E+00 0.3660255 0.7320511 1.098076 1.464102 1.830127 2.196153 2.562178 2.928203 3.294229 3.660254 1.515412 0.0000000E+00 0.2782125 0.5564247 0.8346372 1.112849 1.391062 1.669274 1.947486 2.225699 2.503911 2.782123	40 45 50 	d1(gama 5.559950 6.059950 6.059950 7.059950 7.059950 7.559950 8.059951 9.559951 9.559951 10.05995 10.55995 beta= 0.600 gama 1.011504 2.011504 2.011504 4.511504 4.011504 4.511504 5.011504 5.511504 6.011504 beta= 0.600 gama 1.047016 2.547016 2.047016 3.547016 3.547016	beta 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.6000000	alfa 55	0.0000000E+00 4.4910204E-02 8.9820325E-02 0.1347304 0.1796406 0.2245508 0.2694609 0.3143710 0.3592812 0.4041913 0.4491014 1.011504 0.0000000E+00 2.272913 4.545825 6.818738 9.091650 11.36456 13.63748 15.91039 18.18330 20.45621 22.72912 1.047016 0.0000000E+00 1.108010 2.216020 3.324029 4.432040 5.540050
d1(3.719792 4.219792 4.719792 5.219792 5.219792 6.219792 eta= 0.500 gama 1.341506 1.841506 2.341506 2.341506 3.341506 4.341506 5.341506 5.341506 6.341506 6.341506 6.341506 6.341506 5.341506 5.341506 5.341506 5.341506 5.341506 5.341506 5.341506 5.341506 5.341506 5.341506 5.341506 5.341506 5.341506 5.341506 5.341506 6.341506 6.341506 6.341506 eta= 0.500 gama 1.515412 2.515412 4.515412 5.515412 6.515412 6.515412 6.515412 6.515412 6.515412	0.5000000 0.5000000	25 = 25 = 25 = 25 = 25 = 25 = 25 = 25 = 25 = 30 = 30 = 30 = 30 = 30 = 30 = 30 = 30 = 30 = 30 = 30 = 35 =	2.403515 2.884219 3.364922 3.845624 4.326327 4.807031 1.341506 0.0000000E+00 0.3660255 0.7320511 1.098076 1.464102 1.830127 2.196153 2.562178 2.928203 3.294229 3.660254 1.515412 0.0000000E+00 0.2782125 0.5564247 0.8346372 1.112849 1.391062 1.669274 1.947486 2.225699 2.503911 2.782123	40 45 50 55	d1(d1(d1(d1(d1(d1(d1(d1(d1(d1(gama 5.559950 6.059950 6.059950 7.059950 7.559950 7.559950 8.059951 8.559951 9.059951 9.559951 10.05995 10.55995 beta= 0.600 gama 1.011504 2.011504 2.511504 3.511504 4.011504 4.511504 5.011504 5.011504 5.011504 5.011504 6.011504 6.011504 6.011504 6.011504 6.011504 6.011504 6.011504 6.011504 6.011504 6.011504 6.011504 6.011504	beta 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.5000000 0.6000000	alfa 55	0.0000000E+00 4.4910204E-02 8.9820325E-02 0.1347304 0.1796406 0.2245508 0.2694609 0.3143710 0.3592812 0.4041913 0.4491014 1.011504 0.0000000E+00 2.272913 4.545825 6.818738 9.091650 11.36456 13.63748 15.91039 18.18330 20.45621 22.72912 1.047016 0.0000000E+00 1.108010 2.216020 3.324029 4.432040 5.540050 6.648058

TABLE 1-continued

TABLE 1-continued

	Design Para	meters for CSS	C Tube Fitting,	(d1= Δ L/R ϵ_p).			Design Para	meters for CSS	C Tube Fitting	g, (d1=ΔL/Rε _p).	
d1(5.547016	0.6000000	10)=	9.972089		d1(3.493007	0.6000000	40)=	0.2583195	_
dl(6.047016	0.6000000	10)=	11.08010		d1(3.993007	0.6000000	40)=	0.3874791	
						d1(4.493007	0.6000000	40)=	0.5166388	
gama(b	eta= 0.60	00000 alfa=		.109838		d 1(4.993007	0.6000000	40)=	0.6457986	
	gama	beta	alfa			d1(5.493007	0.6000000	40)=	0.7749582	
d1(1.109838	0.6000000	15)=	0.0000000E+00		d1(5.993007	0.6000000	40)=	0.9041179	
d1(1.609838	0.6000000	15)=	0.7069143	10	d1(6.493007	0.6000000	40)≔	1.033278	
d1(2.109838	0.6000000	15)=	1.413829	10	d1(6.993007	0.6000000	40)=	1.162437	
d1(2.609838	0.6000000	15)=	2.120744		d1(7.493007	0.6000000	40)=	1.291597	
d1(3.109838	0.6000000	15)≈	2.827658							_
d1(3.609838	0.6000000	15)=	3.534573		gama(beta= 0.600	00000 alfa=	45) >	3.800942	
d1(4.109838	0.6000000	15)=	4.241487		υ .	gama	beta	alfa		
d1(4.609838	0.6000000	15)=	4.948401		d1(3.800942	0.6000000	45)=	0.0000000E+00	
dl(5.109838	0.6000000	15)≔	5.655315	15	d1(4.300942	0.6000000	45)=	7.5736046E-02	
d1(5.609838	0.6000000	15)=	6.362230		d1(4.800942	0.6000000	45)=	0.1514720	
dl(6.109838	0.6000000	15)=	7.069144		d1(5.300942	0.6000000	45)=	0.2272079	
	0.107050	0.000000		71007177		d1(5.800942	0.6000000	45)=	0.3029439	
gama(b	eta= 0.60i	00000 alfa=	20) > 1	.206618		d1(6.300942	0.6000000	45)=	0.3786799	
Summo	gama	beta	alfa	200010		d1(6.800942	0.6000000	45)=	0.4544158	
d1(1.206618	0.6000000		0.0000000E+00	20	d1(7.300942	0.6000000	45)=	0.5301518	
dl(1.706618	0.6000000	20)=	0.4965974		d1(7.800942	0.6000000	45)=	0.6058878	
d1(2.206618	0.6000000	20)=	0.9931949		d1(8.300942	0.6000000	45)=	0.6816237	
dl(2.706618	0.6000000	20)=	1.489792		d1(8.800942	0.6000000	45)=	0.7573596	
d1(3.206618	0.6000000	20)=	1.986390		u1(0.000942	0.0000000	45)-	0.7373390	
d1(3.706618	0.6000000	20)=	2.482987		gama(hata- 0.600	00000 alfa=	50) >	9.228890	
	4.206618	0.6000000		2.979584	25	gama(beta	alfa	9.220090	
dl(4.206618	0.6000000	20)= 20)=	3.476182	23	417	gama 9.228890	0.6000000		0.0000000E+00	
d1(d1(5.206618	0.6000000	20)= 20)≈	3.972780		d1(d1(9.228890	0.6000000	50)= 50)=	2,7927648E-02	
d1(5.706618	0.6000000	20)=	4.469377		d1(10.22889	0.6000000	50)=	5.5855297E-02	
d 1(6.206618	0.6000000	20)=	4.965974		d1(10.72889	0.6000000	50)=	8.3782844E-02	
	0.60	00000 10	05)	0.400.56		d1(11.22889	0.6000000	50)=	0.1117105	
gama(b		00000 alfa=		.349856	30	d1(11.72889	0.6000000	50)=	0.1396381	
	gama	beta	alfa			d1(12.22889	0.6000000	50)=	0.1675658	
d1(1.349856	0.6000000		0.0000000E+00		d1(12.72889	0.6000000	50)=	0.1954933	
d1(1.849856	0.6000000	25)=	0.3623931		d1(13.22889	0.6000000	50)=	0.2234210	
d1(2.349856	0.6000000	25)=	0.7247862		d1(13.72889	0.6000000	50)=	0.2513486	
		η κηηηηη	75 _	1 007170				A GOODOO	50)=	0.2792763	
d1(2.849856	0.6000000	25)=	1.087179		d1(14.22889	0.6000000	<i>50)</i> -	0.2772702	
d1(d1(3.349856	0.6000000	25)=	1.449572	35			· · · · · · · · · · · · · · · · · · ·			
d1(d1(d1(3.349856 3.849856	0.6000000 0.6000000	25)= 25)=	1.449572 1.811965	35	gama(00000 alfa=	5) >	1.017952	
d1(d1(3.349856 3.849856 4.349856	0.6000000 0.6000000 0.6000000	25)= 25)= 25)=	1.449572 1.811965 2.174359	35	gama(beta= 0.700 gama	00000 alfa= beta	5) > alfa	1.017952	
d1(d1(d1(d1(d1(3.349856 3.849856 4.349856 4.849856	0.6000000 0.6000000 0.6000000 0.6000000	25)= 25)= 25)= 25)=	1.449572 1.811965 2.174359 2.536751	35	gama(beta= 0.700 gama 1.017952	00000 alfa= beta 0.7000000	5) > alfa 5)=	1.017952 0.0000000E+00	
d1(d1(d1(d1(3.349856 3.849856 4.349856	0.6000000 0.6000000 0.6000000	25)= 25)= 25)= 25)= 25)=	1.449572 1.811965 2.174359 2.536751 2.899144	35	gama(beta= 0.700 gama 1.017952 1.517952	00000 alfa= beta 0.7000000 0.7000000	5) > alfa 5)= 5)=	1.017952 0.0000000E+00 1.699228	
d1(d1(d1(d1(d1(3.349856 3.849856 4.349856 4.849856 5.349856 5.849856	0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000	25)= 25)= 25)= 25)= 25)= 25)=	1.449572 1.811965 2.174359 2.536751 2.899144 3.261538	35	gama(beta= 0.700 gama 1.017952 1.517952 2.017952	00000 alfa= beta 0.7000000 0.7000000 0.7000000	5) > alfa 5)= 5)= 5)=	1.017952 0.0000000E+00 1.699228 3.398454	
d1(d1(d1(d1(d1(d1(3.349856 3.849856 4.349856 4.849856 5.349856	0.600000 0.600000 0.600000 0.600000 0.600000	25)= 25)= 25)= 25)= 25)=	1.449572 1.811965 2.174359 2.536751 2.899144		gama() d1(d1(beta= 0.700 gama 1.017952 1.517952	00000 alfa= beta 0.7000000 0.7000000	5) > alfa 5)= 5)= 5)= 5)=	1.017952 0.0000000E+00 1.699228	
d1(d1(d1(d1(d1(d1(d1(d1(3.349856 3.849856 4.349856 4.849856 5.349856 5.849856 6.349856	0.600000 0.600000 0.600000 0.600000 0.600000 0.600000	25)= 25)= 25)= 25)= 25)= 25)= 25)=	1.449572 1.811965 2.174359 2.536751 2.899144 3.261538 3.623930	35	gama() d1(d1(d1(beta= 0.700 gama 1.017952 1.517952 2.017952	00000 alfa= beta 0.7000000 0.7000000 0.7000000	5) > alfa 5)= 5)= 5)= 5)= 5)=	1.017952 0.0000000E+00 1.699228 3.398454	
d1(d1(d1(d1(d1(d1(d1(d1(3.349856 3.849856 4.349856 4.849856 5.349856 5.849856 6.349856	0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000	25)= 25)= 25)= 25)= 25)= 25)= 25)=	1.449572 1.811965 2.174359 2.536751 2.899144 3.261538		gama() d1(d1(d1(d1(beta= 0.700 gama 1.017952 1.517952 2.017952 2.517952	00000 alfa= beta 0.7000000 0.7000000 0.7000000 0.7000000	5) > alfa 5)= 5)= 5)= 5)= 5)= 5)=	1.017952 0.0000000E+00 1.699228 3.398454 5.097681	
d1(d1(d1(d1(d1(d1(d1(3.349856 3.849856 4.349856 4.849856 5.349856 5.849856 6.349856	0.600000 0.600000 0.600000 0.600000 0.600000 0.600000	25)= 25)= 25)= 25)= 25)= 25)= 25)=	1.449572 1.811965 2.174359 2.536751 2.899144 3.261538 3.623930		gama() d1(d1(d1(d1(d1(d1(beta= 0.700 gama 1.017952 1.517952 2.017952 2.517952 3.017952	00000 alfa= beta 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000	5) > alfa 5	1.017952 0.0000000E+00 1.699228 3.398454 5.097681 6.796908	
d1(d1(d1(d1(d1(d1(d1(3.349856 3.849856 4.349856 4.849856 5.349856 5.849856 6.349856	0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000	25)= 25)= 25)= 25)= 25)= 25)= 25)= 30) > 1	1.449572 1.811965 2.174359 2.536751 2.899144 3.261538 3.623930		gama() d1(d1(d1(d1(d1(d1(d1(beta= 0.700 gama 1.017952 1.517952 2.017952 2.517952 3.017952 3.517952	00000 alfa= beta 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000	5) > alfa 5	1.017952 0.0000000E+00 1.699228 3.398454 5.097681 6.796908 8.496135	
d1(d1(d1(d1(d1(d1(d1(d1(3.349856 3.849856 4.349856 4.849856 5.349856 6.349856 eta= 0.600 gama	0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000	25)= 25)= 25)= 25)= 25)= 25)= 25)= 30) > 1	1.449572 1.811965 2.174359 2.536751 2.899144 3.261538 3.623930		gama() d1(d1(d1(d1(d1(d1(d1(d1(d1(beta= 0.700 gama 1.017952 1.517952 2.017952 2.517952 3.017952 3.517952 4.017952	00000 alfa= beta 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000	5) > alfa 5	1.017952 0.0000000E+00 1.699228 3.398454 5.097681 6.796908 8.496135 10.19536	
d1(d1(d1(d1(d1(d1(d1(d1(d1(d1(3.349856 3.849856 4.349856 4.849856 5.349856 5.849856 6.349856 eta= 0.600 gama 1.563856	0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000	25)= 25)= 25)= 25)= 25)= 25)= 25)= 30) > 1 alfa 30)=	1.449572 1.811965 2.174359 2.536751 2.899144 3.261538 3.623930 .563856 0.0000000E+00		gama() d1(beta= 0.700 gama 1.017952 1.517952 2.017952 2.517952 3.017952 3.517952 4.017952 4.517952	00000 alfa= beta 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000	5) > alfa 5	1.017952 0.000000E+00 1.699228 3.398454 5.097681 6.796908 8.496135 10.19536 11.89459	
d1(3.349856 3.849856 4.349856 4.849856 5.349856 5.849856 6.349856 eta= 0.600 gama 1.563856 2.063856	0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000	25)= 25)= 25)= 25)= 25)= 25)= 25)= 30) > 1 alfa 30)= 30)=	1.449572 1.811965 2.174359 2.536751 2.899144 3.261538 3.623930 563856 0.0000000E+00 0.2660254		gama() d1(beta= 0.700 gama 1.017952 1.517952 2.017952 2.517952 3.017952 4.017952 4.517952 5.017952	00000 alfa= beta 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000	5) > alfa 5	1.017952 0.0000000E+00 1.699228 3.398454 5.097681 6.796908 8.496135 10.19536 11.89459 13.59381	
d1(3.349856 3.849856 4.349856 4.849856 5.349856 5.849856 6.349856 eta= 0.600 gama 1.563856 2.063856 2.563856 3.563856 3.563856	0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000	25)= 25)= 25)= 25)= 25)= 25)= 25)= 30) > 1 alfa 30)= 30)= 30)= 30)= 30)= 30)=	1.449572 1.811965 2.174359 2.536751 2.899144 3.261538 3.623930 563856 0.0000000E+00 0.2660254 0.5320508 0.7980763 1.064102	40	gama() d1(beta= 0.700 gama 1.017952 1.517952 2.017952 2.517952 3.017952 3.517952 4.017952 4.517952 5.017952 6.017952	00000 alfa= beta 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000	5) > alfa 5	1.017952 0.000000E+00 1.699228 3.398454 5.097681 6.796908 8.496135 10.19536 11.89459 13.59381 15.29304 16.99227	_
d1(3.349856 3.849856 4.349856 5.349856 5.849856 6.349856 0.349856 2.063856 2.063856 2.563856 3.063856 4.063856 4.063856	0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000 0.6000000	25)= 25)= 25)= 25)= 25)= 25)= 25)= 30)= 30)= 30)= 30)= 30)= 30)= 30)= 30)=	1.449572 1.811965 2.174359 2.536751 2.899144 3.261538 3.623930 563856 0.0000000E+00 0.2660254 0.5320508 0.7980763 1.064102 1.330127	40	gama() d1(beta= 0.700 gama 1.017952 1.517952 2.017952 2.517952 3.017952 3.517952 4.017952 4.517952 5.017952 6.017952	00000 alfa= beta 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000	5) > alfa 5	1.017952 0.0000000E+00 1.699228 3.398454 5.097681 6.796908 8.496135 10.19536 11.89459 13.59381 15.29304	_
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TABLE 1-continued

TABLE 1-continued

	Design Para	meters for CSS	C Tube Fitting	g, (d1=ΔL/Rε _p).			Design Para	meters for CSS	C Tube Fitting	g, (d1= Δ L/R ϵ_p).	
d1(5.676332	0.7000000	15)=	4.623564	 5	d1(51.24860	0.7000000	45)=	1.0050535E-02	
d1(6.176332	0.7000000	15)=	5.137293		d1(51.74860	0.7000000	45)=	1.5075803E-02	
`						dI(52.24860	0.7000000	45)=	2.0101070E-02	
gama(b	neta= 0.70	00000 alfa=	20) >	1.341623		d1(52.74860	0.7000000	45)=	2.5126338E-02	
3 (-	gama	beta	alfa			d1(53.24860	0.7000000	45)=	3.0151606E-02	
d1(1.341623	0.7000000	20)=	0.0000000E+00		d1(53.74860	0.7000000	45)=	3.5176873E-02	
d1(1.841623	0.7000000	20)=	0.3504074	10	d1(54.24860	0.7000000	45)=	4.0202141E-02	
d1(2.341623	0.7000000	20)=	0.7008147	10	d1(54.74860	0.7000000	45)=	4.5227408E-02	
d1(2.841623	0.7000000	20)=	1.051222		d1(55.24860	0.7000000	45)=	5.0252676E-02	
d1(3.341623	0.7000000	20)=	1.401629							
d1(3.841623	0.7000000	20)=	1.752036		gamai	(beta= 0.80	00000 alfa=	5) >	1.030974	
d1(4.341623	0.7000000	20)=	2.102443		Burn	gama	beta	alfa	2.000,7.	
d1(4.841623	0.7000000	20)=	2.452851		d1(1.030974	0.8000000	5)=	0.0000000E+00	
d1(5.341623	0.7000000	20)=	2.803258	15	d1(1.530974	0.8000000	5)=	1.125542	
d1(5.841623	0.7000000	20)=	3.153665		d1(2.030974	0.8000000	5)=	2.251082	
d1(6.341623	0.7000000	20)=	3.504072		d1(2.530974	0.8000000	5)=	3.376623	
u1(0.541025	0.7000000		3.304072		d1(3.030974	0.8000000	5)=	4.502163	
gama(t	ωta 0.70	00000 alfa=	25) >	1.606009		d1(3.530974	0.8000000	5)=	5.627705	
gama(t	gama	beta	alfa	1.000009		d1(4.030974	0.8000000	5)=	6.753245	
d1(1.606009	0.7000000	25)=	0.0000000E+00	20	d1(4.530974	0.8000000	5)=	7.878787	
d1(2.106009	0.7000000	25)=	0.2440831		d1(5.030974	0.8000000	5)=	9.004327	
d1(2.606009	0.7000000	25)=	0.4881659		d1(5.530974	0.8000000	5)=	10.12987	
d1(3.106009	0.7000000	25)=	0.7322490		d1(6.030974	0.8000000	5)=	11.25541	
d1(3.606009	0.7000000	25)=	0.9763318			2.323771	2.300000			
dI(4.106009	0.7000000	25)=	1.220415		gamai	beta= 0.80	00000 alfa=	10) >	1.130530	
d1(4.606009	0.7000000	25)=	1.464498	25	Sama	gama 0.60	beta	alfa		
d1(5.106009	0.7000000	25)=	1.708581	دے	dl(1.130530	0.8000000	10)=	0.0000000E+00	
d1(5.606009	0.7000000	25)=	1.952664		d1(1.630530	0.8000000	10)=	0.5321329	
d1(6.106009	0.7000000	25)=	2.196746		d1(2.130530	0.8000000	10)=	1.064265	
d1(6.606009	0.7000000	25)=	2.440830		d1(2.630530	0.8000000	10)=	1.596398	
uit	0.000009	0.7000000		2.440630		d1(3.130530	0.8000000	10)= 10)=	2.128531	
gama(b	ota 0.70	00000 alfa=	30) >	2.054056		d1(3.630530	0.8000000	10)=	2.660663	
gama(t	gama	beta	alfa	2.034030	30	d1(4.130530	0.8000000	10)=	3.192796	
d1(2.054056	0.7000000	30)=	0.0000000E+00		d1(4.630530	0.8000000	10)=	3.724929	
d1(2.554056	0.7000000	30)=	0.1660255		d1(5.130530	0.8000000	10)=	4.257061	
dl(3.054056	0.7000000	30)=	0.3320508		d1(5.630530	0.8000000	10)=	4.789194	
d1(3.554056	0.7000000	30)=	0.4980763		d1(6.130530	0.8000000	10)=	5.321326	
			JU)			uı(0.130330	0.0000000	10)-	3.321320	
417	4 054056	0.7000000	30)-	0.6641017							
d1(4.054056 4.554056	0.7000000	30)= 30)=	0.6641017 0.8301272	35	gama(heta=: 0.800	00000 alfa=	15) >	1 322975	—
d1(4.554056	0.7000000	30)=	0.8301272	35	gama(00000 alfa=		1.322975	
d1(d1(4.554056 5.054056	0.7000000 0.7000000	30)= 30)=	0.8301272 0.9961525	35	_	gama	beta	alfa		
d1(d1(d1(4.554056 5.054056 5.554056	0.7000000 0.7000000 0.7000000	30)= 30)= 30)=	0.8301272 0.9961525 1.162178	35	d1(gama 1.322975	beta 0.8000000	alfa 15)=	0.0000000E+00	
d1(d1(d1(d1(4.554056 5.054056 5.554056 6.054056	0.7000000 0.7000000 0.7000000 0.7000000	30)= 30)= 30)= 30)=	0.8301272 0.9961525 1.162178 1.328203	35	d1(d1(gama 1.322975 1.822975	beta 0.8000000 0.8000000	alfa 15)= 15)=	0.0000000E+00 0.3205443	
d1(d1(d1(d1(d1(4.554056 5.054056 5.554056 6.054056 6.554056	0.700000 0.700000 0.700000 0.700000 0.700000	30)= 30)= 30)= 30)= 30)=	0.8301272 0.9961525 1.162178 1.328203 1.494229	35	d1(d1(d1(gama 1.322975 1.822975 2.322975	beta 0.8000000 0.8000000 0.8000000	alfa 15)= 15)= 15)=	0.0000000E+00 0.3205443 0.6410881	
d1(d1(d1(d1(4.554056 5.054056 5.554056 6.054056	0.7000000 0.7000000 0.7000000 0.7000000	30)= 30)= 30)= 30)=	0.8301272 0.9961525 1.162178 1.328203	35	d1(d1(d1(d1(gama 1.322975 1.822975 2.322975 2.822975	beta 0.8000000 0.8000000 0.8000000 0.8000000	alfa 15)= 15)= 15)= 15)=	0.0000000E+00 0.3205443 0.6410881 0.9616324	
d1(d1(d1(d1(d1(d1(4.554056 5.054056 5.554056 6.054056 6.554056 7.054056	0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000	30)= 30)= 30)= 30)= 30)= 30)=	0.8301272 0.9961525 1.162178 1.328203 1.494229 1.660254		d1(d1(d1(d1(d1(gama 1.322975 1.822975 2.322975 2.822975 3.322975	beta 0.8000000 0.8000000 0.8000000 0.8000000 0.8000000	alfa 15)= 15)= 15)= 15)= 15)=	0.0000000E+00 0.3205443 0.6410881 0.9616324 1.282176	
d1(d1(d1(d1(d1(4.554056 5.054056 5.554056 6.054056 6.554056 7.054056	0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000	30)= 30)= 30)= 30)= 30)= 30)=	0.8301272 0.9961525 1.162178 1.328203 1.494229		d1(d1(d1(d1(d1(d1(gama 1.322975 1.822975 2.322975 2.822975 3.322975 3.822975	beta 0.8000000 0.8000000 0.8000000 0.8000000 0.8000000	alfa 15)= 15)= 15)= 15)= 15)= 15)=	0.000000E+00 0.3205443 0.6410881 0.9616324 1.282176 1.602720	
d1(d1(d1(d1(d1(d1(gama(b	4.554056 5.054056 5.554056 6.054056 6.554056 7.054056 eta= 0.700 gama	0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000	30)= 30)= 30)= 30)= 30)= 30)= 35) > alfa	0.8301272 0.9961525 1.162178 1.328203 1.494229 1.660254		d1(d1(d1(d1(d1(d1(d1(gama 1.322975 1.822975 2.322975 2.822975 3.322975 3.822975 4.322975	beta 0.8000000 0.8000000 0.8000000 0.8000000 0.8000000 0.8000000	alfa 15)= 15)= 15)= 15)= 15)= 15)= 15)= 15)=	0.000000E+00 0.3205443 0.6410881 0.9616324 1.282176 1.602720 1.923264	
d1(d1(d1(d1(d1(d1(gama(b	4.554056 5.054056 5.554056 6.054056 6.554056 7.054056 eta= 0.700 gama 2.932765	0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 alfa= beta 0.7000000	30)= 30)= 30)= 30)= 30)= 30)= 35) > alfa 35)=	0.8301272 0.9961525 1.162178 1.328203 1.494229 1.660254 2.932765 0.0000000E+00		d1(d1(d1(d1(d1(d1(d1(d1(gama 1.322975 1.822975 2.322975 2.822975 3.322975 3.822975 4.322975 4.822975	beta 0.800000 0.800000 0.800000 0.800000 0.800000 0.8000000 0.8000000 0.8000000	alfa 15)= 15)= 15)= 15)= 15)= 15)= 15)= 15)= 15)=	0.0000000E+00 0.3205443 0.6410881 0.9616324 1.282176 1.602720 1.923264 2.243809	
d1(d1(d1(d1(d1(d1(gama(b	4.554056 5.054056 5.554056 6.054056 6.554056 7.054056 eta= 0.700 gama 2.932765 3.432765	0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 0.7000000 alfa= beta 0.7000000 0.7000000	30)= 30)= 30)= 30)= 30)= 30)= 35) > alfa 35)= 35)=	0.8301272 0.9961525 1.162178 1.328203 1.494229 1.660254 2.932765 0.0000000E+00 0.1038678		d1(d1(d1(d1(d1(d1(d1(d1(gama 1.322975 1.822975 2.322975 2.822975 3.322975 3.822975 4.322975 4.822975 5.322975	beta 0.800000 0.800000 0.800000 0.800000 0.800000 0.800000 0.8000000 0.8000000 0.8000000 0.8000000	alfa 15)= 15)= 15)= 15)= 15)= 15)= 15)= 15)= 15)= 15)=	0.000000E+00 0.3205443 0.6410881 0.9616324 1.282176 1.602720 1.923264 2.243809 2.564352	
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d1(4.554056 5.054056 5.054056 5.554056 6.054056 6.554056 7.054056 7.054056 eta= 0.700 gama 2.932765 3.432765 4.432765 4.932765 5.432765 6.932765 7.432765 7.932765 7.432765 7.932765 0.379220 6.379220 6.379220 6.379220 7.379220 8.379220 8.379220 9.379220 9.879220 9.879220 9.879220 9.879220 9.879220 9.879220	0.7000000 0.7000000	30 = 30 = 30 = 30 = 30 = 30 = 30 = 30 = 30 = 30 = 30 = 35 = 35 = 35 = 35 = 35 = 35 = 35 = 35 = 35 = 40 =	0.8301272 0.9961525 1.162178 1.328203 1.494229 1.660254 2.932765 0.0000000E+00 0.1038678 0.2077354 0.3116030 0.4154705 0.5193383 0.6232059 0.7270735 0.8309411 0.9348087 1.038677 5.379220 0.0000000E+00 5.1373534E-02 0.1027469 0.1541205 0.2054938 0.2568674 0.3082408 0.3596143 0.4109877 0.4623612 0.5137346	40 45 50 	di(gama 1.322975 1.822975 2.322975 2.822975 3.322975 3.322975 4.322975 4.322975 5.322975 5.322975 5.322975 6.32297	beta 0.8000000	alfa 15)= 15)= 15)= 15)= 15)= 15)= 15)= 15)= 15)= 15)= 20)= 20)= 20)= 20)= 20)= 20)= 20)= 20)= 20)= 20)= 20)= 20)= 20)= 25) > alfa 25)= 25)= 25)= 25)= 25)=	0.0000000E+00 0.3205443 0.6410881 0.9616324 1.282176 1.602720 1.923264 2.243809 2.564352 2.884897 3.205441 1.669916 0.0000000E+00 0.2042170 0.4084340 0.6126506 0.8168676 1.021085 1.225302 1.429518 1.633735 1.837952 2.042169 2.344067 0.0000000E+00 0.1257728 0.2515459 0.3773187 0.5030918	
d1(4.554056 5.054056 5.054056 6.054056 6.054056 6.554056 7.054056 eta= 0.700 gama 2.932765 3.432765 4.932765 4.932765 5.932765 6.432765 7.932765 6.432765 7.432765 7.432765 7.432765 7.432765 7.432765 7.432765 7.432765 7.432765 8.79220 6.379220 6.379220 7.379220 7.379220 7.379220 9.879220 9.879220 9.879220 9.879220 9.879220 9.879220 9.879220 9.879220 9.879220 9.879220 9.879220 9.879220	0.7000000 0.7000000	30 = 30 = 30 = 30 = 30 = 30 = 30 = 30 = 30 = 30 = 30 = 35 = 35 = 35 = 35 = 35 = 35 = 35 = 35 = 35 = 35 = 35 = 35 = 40 =	0.8301272 0.9961525 1.162178 1.328203 1.494229 1.660254 2.932765 0.0000000E+00 0.1038678 0.2077354 0.3116030 0.4154705 0.5193383 0.6232059 0.7270735 0.8309411 0.9348087 1.038677 5.379220 0.0000000E+00 5.1373534E-02 0.1027469 0.1541205 0.2054938 0.2568674 0.3082408 0.3596143 0.4109877 0.4623612 0.5137346	40 45 50 	di(gama 1.322975 1.822975 2.322975 2.322975 3.322975 3.322975 4.322975 4.322975 5.322975 5.322975 6.32297 6.32297 6.32297 6.32297 6.	beta 0.8000000	alfa 15	0.0000000E+00 0.3205443 0.6410881 0.9616324 1.282176 1.602720 1.923264 2.243809 2.564352 2.884897 3.205441 1.669916 0.0000000E+00 0.2042170 0.4084340 0.6126506 0.8168676 1.021085 1.225302 1.429518 1.633735 1.837952 2.042169 2.344067 0.0000000E+00 0.1257728 0.2515459 0.3773187 0.5030918 0.6288645	
d1(4.554056 5.054056 5.054056 5.554056 6.054056 6.554056 7.054056 eta= 0.700 gama 2.932765 3.432765 3.932765 4.932765 5.432765 6.932765 7.432765 0.379220 8.379220 9.379220 9.379220 9.379220 9.379220 9.379220 9.379220 9.379220 9.379220 9.379220 9.379220 9.379220 9.379220 9.379220 9.379220	0.7000000 0.7000000	30 = 30 = 30 = 30 = 30 = 30 = 30 = 30 = 30 = 30 = 30 = 35 =	0.8301272 0.9961525 1.162178 1.328203 1.494229 1.660254 2.932765 0.0000000E+00 0.1038678 0.2077354 0.3116030 0.4154705 0.5193383 0.6232059 0.7270735 0.8309411 0.9348087 1.038677 5.379220 0.0000000E+00 5.1373534E-02 0.1027469 0.1541205 0.2054938 0.2568674 0.3082408 0.3596143 0.4109877 0.4623612 0.5137346 50.24860	40 45 50 55	di(gama 1.322975 1.822975 2.322975 2.822975 3.322975 3.322975 4.322975 4.322975 5.322975 5.322975 5.322975 6.32297	beta 0.8000000	alfa 15)= 15)= 15)= 15)= 15)= 15)= 15)= 15)= 15)= 20) > alfa 20)= 20)= 20)= 20)= 20)= 20)= 20)= 20)= 20)= 20)= 25)= 25)= 25)= 25)= 25)= 25)= 25)= 25)=	0.0000000E+00 0.3205443 0.6410881 0.9616324 1.282176 1.602720 1.923264 2.243809 2.564352 2.884897 3.205441 1.669916 0.0000000E+00 0.2042170 0.4084340 0.6126506 0.8168676 1.021085 1.225302 1.429518 1.633735 1.837952 2.042169 2.344067 0.0000000E+00 0.1257728 0.2515459 0.3773187 0.5030918 0.6288645 0.7546374	

TABLE 1-continued

	Design Para	uneters for CSS	SC Tube Fitting, (d1= Δ L/R ϵ_p).	
d1(d1(6.844068 7.344068	0.8000000 0.8000000	25)= 1.131956 25)= 1.257729	5
gama((beta= 0.80	00000 alfa=	30) > 4.029140	
•	gama	beta	alfa	
dl(4.029140	0.8000000	30)= 0.0000000E+00	
d1(d1(4.529140 5.029140	0.8000000	30 = 6.6025421E-02 30 = 0.1320508	10
dl(5.529140	0.8000000	30)= 0.1320308	
dl(6.029140	0.8000000	30)= 0.2641015	
dl(6.529140	0.8000000	30)= 0.3301269	
d1(7.029140	0.8000000	30)= 0.3961523	
dl(7.529140	0.8000000	30)= 0.4621775	15
dl(8.029140	0.8000000	30)= 0.5282030	13
d1(8.529140	0.8000000	30)= 0.5942284	
dl(9.029140	0.8000000	30)= 0.6602538	
gama(00000 alfa=	35) > 14.74223	
d1(gama 14.74223	beta 0.8000000	alfa 35)= 0.000000E+00	20
dl(15.24223	0.8000000	35)= 0.0000000E+00 35)= 1.6695250E-02	20
d1(15.74223	0.8000000	35)= 3.3390671E-02	
dl(16.24223	0.8000000	35 = 5.0085921E-02	
d1(16.74223	0.8000000	35)= 6.6781171E-02	
dl(17.24223	0.8000000	35)= 8.3476588E-02	
d1(17.74223	0.8000000	35)= 0.1001718	25
d1(18.24223	0.8000000	35)= 0.1168671	
dl(18.74223	0.8000000	35)= 0.1335623	
d1(d1(19.24223 19.74223	0.8000000	35)= 0.1502578 35)= 0.1669530	
u1(17.14223	0,8000000		
gama(beta= 0.90 gama	00000 alfa≔ beta	5) > 1.071069 alfa	30
d1(1.071069	0.9000000	5)= 0.0000000E+00	
d1(1.571069	0.9000000	5)= 0.5518552	
dI(2.071069	0.9000000	5)= 1.103712	
d1(2.571069	0.9000000	5)= 1.655567	
dl(3.071069	0.9000000	5)= 2.207422	35
dl(3.571069	0.9000000	5)= 2.759278	22
dl(4.071069	0.9000000	5)= 3.311134	
d1(4.571069	0.9000000	5)= 3.862989 5)= 4.414845	
d1(d1(5.071069 5.571069	0.9000000 0.9000000	5)= 4.414845 5)= 4.966701	
d1(6.071069	0.9000000	5)= 5.518556	
	hata 0.000	00000 -15-	10) - 1,210000	40
gama(gama 0.90	00000 alfa= beta	10) > 1.319999 alfa	
d1(1.319999	0.9000000	10)= 0.0000000E+00	
d1(1.819999	0.9000000	10)= 0.2441943	
d1(2.319999	0.9000000	10 = 0.4883885	
d1(2.819999	0.9000000	10)= 0.7325828	45
d1(3.319999	0.9000000	10)= 0.9767771	
d1(3.819999 4.319999	0.9000000	10)= 1.220971 10 \= 1.465166	
d1(d1(4.819999	0.9000000 0.9000000	10)= 1.465166 10)= 1.709360	
d1(5.319999	0.9000000	10)= 1.709360	
d1(5.819999	0.9000000	10)= 1.933334	50
d1(6.319999	0.9000000	10)= 2.441943	50
gama(l	beta= 0.900	00000 alfa=	15) > 1.914492	
	gama	beta	alfa	
dl(1.914492	0.9000000	15)= 0.0000000E+00	
dl(2.414492	0.9000000	15)= 0.1273588	55
d1(d1(2.914492 3.414492	0.9000000	15)= 0.2547180 15)= 0.3820768	-
d1(3.41 44 92 3.914492	0.9000000 0.9000000	15)= 0.3820768 15)= 0.5094356	
d1(4.414492	0.9000000	15)= 0.6367944	
d1(4.914492	0.9000000	15)= 0.7641537	
d1(5.414492	0.9000000	15)= 0.8915125	
d1(5.914492	0.9000000	15)= 1.018871	60
d1(6.414492	0.9000000	15)= 1.146230	
d1(6.914492	0.9000000	15)= 1.273589	
gama(l	beta= 0.900	00000 alfa=	20) > 3.652381	
	gama	beta	alfa	
d1(3.652381	0.9000000	20)= 0.0000000E+00	65
dl(4.152381	0.9000000	20)= 5.8026921E-02	

TABLE 1-continued

	Design Para	imeters for CSS	C Tube Fitting, (d1= $\Delta L/R\epsilon_p$).
d1(4.652381	0.9000000	20)= 0.1160535
d1(5.152381	0.9000000	20)= 0.1740804
d1(5.652381	0.9000000	20)= 0.2321070
d1(6.152381	0.9000000	20)= 0.2901340
d1(6.652381	0.9000000	20)= 0.3481605
d1(7.152381	0.9000000	20)= 0.4061875
d1(7.652381	0.9000000	20)= 0.4642141
d1(8.152381	0.9000000	20)= 0.5222410
d1(8.652381	0.9000000	20)= 0.5802675
gama(beta= 0.90	00000 alfa=	25) > 26.48351
	gama	beta	alfa
d1(gama 26.48351	beta 0.9000000	alfa 25)= 0.0000000E+00
d1(d1(
	26.48351	0.9000000	25)= 0.0000000E+00
d1(26.48351 26.98351	0.9000000 0.9000000	25)= 0.0000000E+00 25)= 7.4627930E-03
d1(d1(26.48351 26.98351 27.48351	0.9000000 0.9000000 0.9000000	25)= 0.0000000E+00 25)= 7.4627930E-03 25)= 1.4925586E-02
d1(d1(d1(26.48351 26.98351 27.48351 27.98351	0.9000000 0.9000000 0.9000000 0.9000000	25)= 0.0000000E+00 25)= 7.4627930E-03 25)= 1.4925586E-02 25)= 2.2388378E-02
d1(d1(d1(d1(26.48351 26.98351 27.48351 27.98351 28.48351	0.900000 0.900000 0.900000 0.900000 0.900000	25)= 0.0000000E+00 25)= 7.4627930E-03 25)= 1.4925586E-02 25)= 2.2388378E-02 25)= 2.9851172E-02
d1(d1(d1(d1(d1(26.48351 26.98351 27.48351 27.98351 28.48351 28.98351	0.900000 0.900000 0.900000 0.900000 0.900000 0.900000	25)= 0.0000000E+00 25)= 7.4627930E-03 25)= 1.4925586E-02 25)= 2.2388378E-02 25)= 2.9851172E-02 25)= 3.7313964E-02
d1(d1(d1(d1(d1(d1(26.48351 26.98351 27.48351 27.98351 28.48351 28.98351 29.48351	0.900000 0.900000 0.900000 0.900000 0.900000 0.900000 0.900000	25)= 0.0000000E+00 25)= 7.4627930E-03 25)= 1.4925586E-02 25)= 2.9883172E-02 25)= 3.7313964E-02 25)= 4.4776756E-02
d1(d1(d1(d1(d1(d1(d1(d1(d1(26.48351 26.98351 27.48351 27.98351 28.48351 28.98351 29.48351 29.98351	0.900000 0.900000 0.900000 0.900000 0.900000 0.900000 0.900000 0.900000	25)= 0.0000000E+00 25)= 7.4627930E-03 25)= 1.4925586E-02 25)= 2.2388378E-02 25)= 2.9851172E-02 25)= 3.7313964E-02 25)= 4.4776756E-02 25)= 5.2239552E-02

- I claim:
- 1. A cryogenic tube seal comprising:
- a coupling member comprising a first axisymmetric sloped contact surface;

sealing means comprising a second axisymmetric contact surface, made of a material having a larger coefficient of thermal expansion than said first contact surface, and having a shape which is complementary to that of said first contact surface whereby when said second contact surface is brought into secured contact with said first contact surface at ambient temperature, the contact between the two surfaces is a sealed sloped engagement creating sloped-surface sealing which allows thermal contraction and expansion of said coupling member and said sealing means under temperature cycling from room temperature to temperatures at least as low as about 77K while maintaining sloped-surface sealing between said coupling member and said sealing means and not causing or resulting in the inelastic deformation of either of said surfaces, such that said surfaces can be repeatedly separated and re-engaged wherein said reengagement is a sealed engagement; and

means for bringing said first contact surface and said second contact surface into secured contact.

- 2. The seal of claim 1 wherein said first contact surface is on a first coupling member and said second contact surface is on a second coupling member.
- 3. The seal of claim 1 wherein said second contact surface is a spacer.
 - 4. The seal of claim 3 wherein said spacer is an O-ring.
- 5. The seal of claim 3 wherein said spacer comprises a 60 female-flared contact surface.
 - 6. The seal of claim 3 wherein said spacer comprises a male an-flared contact surface.
 - 7. The seal of claim 3 wherein a cross section through said spacer is H-shaped, whereby the sloped seal is maintained by contraction of said spacer below ambient temperatures or expansion by said spacer above ambient temperatures.

- 8. The seal of claim 2 wherein said means comprises a housing nut made of a material having a larger coefficient of thermal expansion than said first contact surface.
- 9. The seal of claim 3 wherein said means comprises a housing nut made of a material having a larger coefficient of 5 thermal expansion than said first contact surface.
- 10. The seal of claim 7 wherein said means comprises a housing nut made of a material having a smaller coefficient of thermal expansion than does said spacer.

* * * * *

UNITED STATES PATENT AND TRADEMARK OFFICE CERTIFICATE OF CORRECTION

Page 1 of 3

PATENT NO. : 5,620,187

DATED : April 15, 1997

INVENTOR(S) : Lin X. Jia

It is certified that error appears in the above-indentified patent and that said Letters Patent is hereby corrected as shown below:

Column 1: line 23: "J.F.X. Space Center" should read --J.F.K. Space Center--;

line 29: "between taro" should read --between two--;

line 31: "In pan," should read --In part,--;

line 59: "sealing ting must" should read --sealing ring must--;

line 61: "sealing ting is" should read --sealing ring is--;

line 63: "the sealing ting" should read --the sealing ring--.

Column 2: line 27: "known in the an," should read --known in the art--;

lines 36&37: "serf-sealing" should read --self-sealing--.

Column 3: line 60: "pans of contracting serf-sealing" should read --parts of contracting self-sealing--.

Column 4: line 7: "into homing nut" should read --into housing nut--;

line 21: "all pans" should read --all parts--;

line 23: "pans of" should read --parts of--.

Column 6: line 1: "a is the" should read $-\alpha$ is the--;

line 21: "fi is the radius" should read $-\beta$ is the radius--;

UNITED STATES PATENT AND TRADEMARK OFFICE CERTIFICATE OF CORRECTION

PATENT NO. : 5,620,187 Page 2 of 3

DATED : April 15, 1997

INVENTOR(S) : Lin X. Jia

It is certified that error appears in the above-indentified patent and that said Letters Patent is hereby corrected as shown below:

Column 6: lines 3&4: "spacer, γ_0 " should read --spacer, w/R. γ_0 --;

line 5: "tube ends $\gamma_5(\gamma_h\!=\!\varepsilon_h/\varepsilon_p)$ " should read --tube ends. $\gamma_h(\gamma_h\!=\!\varepsilon_h/\varepsilon_p)$ --

line 25: "serf-sealing" should read --self-sealing--;

line 37: "mating pans before" should read --mating parts before--.

Column 7: line 41: "a depends" should read $-\alpha$ depends--;

line 42: "value of fi depends" should read --value of β depends--;

line 51: "and ϵ_{op} =0.06%" should read --and ϵ_{p} =0.06%--;

line 64: "Concept of" should read --concept of--.

Column 8: line 17: "serf-sealing" should read --self-sealing--;

Column 9, line 24: "a fight seal" should read --a tight seal--;

line 52: "serf-sealing" should read --self-sealing--;

UNITED STATES PATENT AND TRADEMARK OFFICE CERTIFICATE OF CORRECTION

PATENT NO. : 5,620,187

: April 15, 1997

Page 3 of 3

INVENTOR(S): Lin X. Jia

It is certified that error appears in the above-indentified patent and that said Letters Patent is hereby corrected as shown below:

Column 9, line 64: "serf-sealing" should read--self-sealing--.

Signed and Sealed this

Twelfth Day of August, 1997

Buce Tehman

Attest:

Attesting Officer

BRUCE LEHMAN

Commissioner of Patents and Trademarks